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THE SCATTERING OF LIGHT IN CRYSTALS.*

BY

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An essay on the molecular diffraction of light [1] published nearly twenty years ago contained a chapter dealing with this subject in which it was shown that a transparent crystal traversed by a beam of light exhibits an opalescence due to diffusion of the light by the ultimate structure of the solid. The phenomenon is strikingly evident when a beam of sunlight traverses a block of transparent ice.[2] It is often possible to find extensive portions in a clear block of ice which are quite free from inclusions, and the track of the sunbeam through such regions appears of a sky-blue colour, the intensity of the opalescence being about 30 times greater than the intensity of a similar track in dust-free air, but only a fraction of its intensity in dust-free water. The finest specimens of transparent quartz exhibit a similar effect,[3] the opalescence, however, being less intense than in ice. In the essay referred to, these effects were explained on the same general principles as the molecular diffusion of light in liquids, namely as the optical consequence of thermodynamic fluctuations of density which disturb the perfect uniformity characteristic of an ideal crystal. Such fluctuations are naturally smaller

* Read by Dr. T. D. Cope, Professor of Physics, University of Pennsylvania, at Medal Day Meeting, Wednesday, May 21, 1941.

[1] C. V. Raman, Calcutta University Press, 1922.

[2] C. V. Raman, *Nature*, **111**, 13 (1923).

[3] C. V. Raman, *Ibid.*, **109**, 42 (1922).

(Note—The Franklin Institute is not responsible for the statements and opinions advanced by contributors in the JOURNAL.)

in a crystal than in a liquid, and the optical effects resulting therefrom should therefore be a lower order of intensity, as is actually observed. Quite early in the history of the subject,[4] it was noticed that the light-scattering power of a crystal is enhanced when the temperature is raised, thus giving support to the hypothesis of its thermodynamic origin.

The subject entered on a new phase with the discovery[5] made early in 1928 that the light diffused by material media consists, in part, of radiations having frequencies different from those of the light traversing the medium. This effect is observed when a powerful source of monochromatic light such as a mercury vapour lamp is used, and the light from such source entering and diffused by the substance under study is spectroscopically examined. New lines or bands are then observed which are not present in the spectrum of the incident light. The frequency differences between each incident radiation and the scattered radiations to which it gives rise are found to be characteristic of the substance studied. An examination of the spectra of monochromatic light diffused by material media thereby affords a powerful method of investigating their ultimate structure. As was emphasized in the paper of March 1928 describing the effect, the phenomenon is universal in character, and is exhibited by matter in all the states of aggregation, viz., gases, liquids, crystals and amorphous solids. The comparative observations of the effect in water and crystalline ice and with optical glass (which is an amorphous solid) reported in the paper showed that a new and powerful tool for investigating the nature of the solid state had become available.

It is not proposed in this paper to survey, even in a superficial manner, the extensive literature, both theoretical and experimental, which has grown up around the subject of light scattering. Indeed, this appears scarcely necessary in view of the excellent treatises dealing with the various aspects of the subject that are now available for the interested student. I shall limit myself in this lecture to raising and seeking to answer the fundamental question, *why does a crystal scatter light?* That such a question needs to be put and answered is

[4] L. Scrivastava, *Proc. Ind. Sc. Cong.*, **10**, 86 (1923).

[5] C. V. Raman, *Ind. Jour. Phys.*, **2**, 387 (1928).

evident when we recall that *on the principles of the wave-theory of light, an ideal homogeneous crystal cannot scatter light.* This result would be true irrespective of whether the crystal is a static structure or a dynamically variable one, provided the variations are everywhere similar and simultaneous. We may easily picture variations of the latter kind; in most crystals, we do not have a single space-lattice of similar and similarly placed atoms, but several such lattices of identical form interpenetrating each other, the equivalent points in each lattice being occupied by atoms of the same kind. If the interpenetrating lattices are displaced by small amounts relatively to each other but without deformation, the crystal structure and its properties would be altered everywhere in the same way, and the solid would therefore remain a homogeneous structure. If, for instance, in a cubic crystal, we assume all the atoms of a particular kind to be displaced one way and all the atoms of another kind to be displaced the opposite way, the common centre of gravity remaining fixed, the cubic symmetry would be destroyed, and the substance wolud become optically uniaxial, but would nevertheless remain a uniform solid and incapable therefore of scattering light. Even if the relative displacement of the lattices were to vary periodically with time, and the optical properties of the crystal become therefore a harmonic function of time, the same result would subsist. We may further extend these considerations and show that if the structure of the solid were to pulsate harmonically both in space and time, the effect on a beam of light traversing it would nevertheless be zero, the disturbances produced in different parts of the solid completely cancelling each other by interference. In one particular case, however, the resultant optical effect would be finite and observable, namely when the pulsation takes the form of harmonic waves whose wave-length and inclination to the direction of progression of the incident radiations satisfy the familiar formula for the monochromatic reflection of light by an optically stratified medium, namely

$$2\mu\lambda^* \operatorname{Sin} \theta = \lambda,$$

where μ is the average refractive index of the medium, λ^* is the spacing of the optical stratifications, θ the glancing angle,

and λ the wave-length of the radiation in *vacuum*. It is thus clear that the scattering of light in an ideal crystal has to be pictured as an internal reflection of the light by the optical stratifications within the solid having the appropriate wave-length and the appropriate inclination to the wave-fronts of the light.

Two further questions arise at this stage, first what is the frequency of the postulated pulsations and secondly, how are such pulsations excited? The first question leads us to classify the possible pulsations of the medium into two groups, both having wave-lengths satisfying the formula and therefore of the same order of magnitude as the wave-length of light, but differing fundamentally in their nature. The first group consists of the acoustic pulsations of the medium. These involve waves of relatively low frequency, which for any given type is inversely proportional to the wave-length. The second group consists of the waves of the optical class, in which the frequency is, to a first approximation, independent of the wave-length. In both cases, since the stratifications are assumed to be periodic in time, the reflection would occur with a change of frequency equal to that of the pulsations. This change may be either a decrease or an increase depending on the relative directions of movement of the light waves and of the optical stratifications in the medium. It is evident from the formula that the change of frequency in the acoustic case would depend on the direction of observation, while in the optical case, it would, to a first approximation, be independent of direction.

The second question as to how the pulsations must be assumed to be excited is best answered by reference to the experimental facts. We shall take a typical case, namely that of diamond. When even a small fragment of this crystal is illuminated by a mercury lamp and an image of it focused on the slit of a spectrograph, a sharp line having a frequency lower than that of the exciting line by 1332 wave-numbers per centimeter is strongly recorded on the plates. Using very large and clear diamonds, a line with increased frequency is also faintly recorded,[6] its intensity being only about 1/500 of

[6] S. Bhagavantam, *Ibid.*, **5**, 573 (1930).

that of the line of diminished frequency. Spectrum plates taken with different directions of scattering show no detectable variations of the frequency shift. It is possible successfully to record the displaced line with diamond held at various temperatures from − 189° C. to 850° C. The photographs (see Fig. 1) show quite definitely that the frequency shift falls off [7]

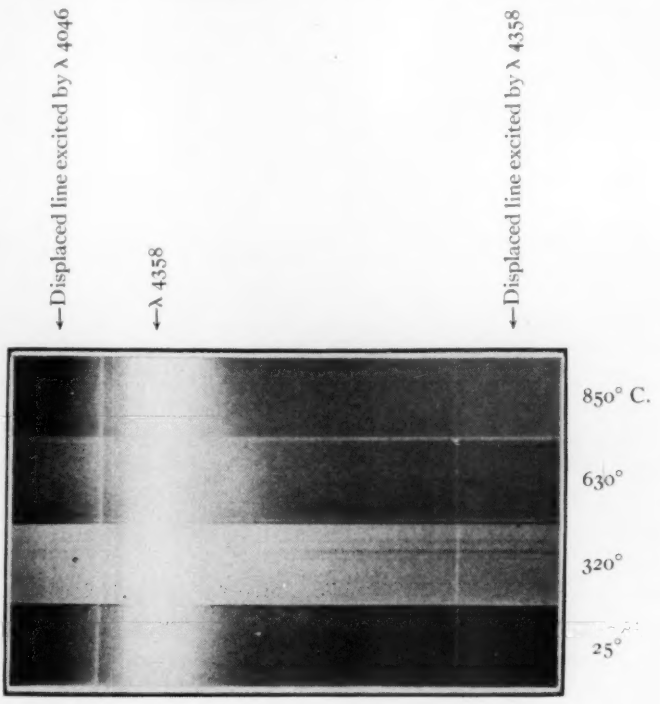

FIG. 1. Spectrum of light scattered by diamond at different temperatures.

with rising temperature at first very slowly and later more quickly, an effect evidently connected with the thermal expansion of the crystal. But there is no striking increase in the intensity of the line over the whole of this large range of temperature. It is evident from the facts that the observed line corresponds to an optical vibration of the crystal lattice having a frequency of 1332 cm.$^{-1}$ and that its appearance cannot be ascribed to the thermal agitation of the crystal

[7] P. G. N. Nayar, *Proc. Ind. Acad. Sci.*, **13**, 400 (1941).

lattice, but *is an effect excited by the incident light itself*, in other words, *a quantum-mechanical phenomenon.*

We are thus compelled to recognise that the pulsations in the crystal lattice which are responsible for the scattering of light are produced by the incident radiation itself. Even when the frequency of a pulsation is so low that it can sensibly be excited by thermal agitation, the scattering by a crystal must in every case be regarded as a quantum-mechanical process, since a change of frequency and therefore also a change of energy level is necessarily involved. In such cases, however, the frequency shift may be either an increase or a decrease, and the intensity of the displaced lines would be a function of temperature instead of being independent of it.

The frequency shifts actually observed with crystals fall into three groups. First, we have pulsations of the acoustic type. In these cases, the frequency shifts are very small and depend on the direction of observation. Their detection requires the use of an interferential spectroscope, e.g., a Lummer-Gehrcke plate or a Fabry-Perot etalon. In practice, experimental difficulties arise due to parasitic illumination and the presence of hyperfine structure components in the incident radiations. Photographs have, however, been obtained and published [8] which show the reality of this type of scattering beyond question, and indicate also that both longitudinal and transverse waves are operative.

The second group of frequency shifts, though belonging to the optical class, are rather small and require clear crystals and spectroscopes of good quality for their being satisfactorily recorded. These shifts are observed with both inorganic and organic crystals and are evidently due to lattice vibrations of relatively low frequency determined by the binding forces which hold the solid together. The frequency shifts, the intensities and the widths of such lines are often highly susceptible to variation with temperature. Particularly striking changes with temperature are noticed in the spectra of substances in which large variations of specific heat or polymorphic transitions are known to occur. The case of quartz (see Fig. 2) is a typical example.[9]

[8] C. V. Raman and C. S. Venkateswaran, *Nature*, **142**, 250 (1938).

[9] T. N. K. Nedungadi, *Proc. Ind. Acad. Sci.*, **11**, 86 (1940).

The third group of lines also belongs to the optical class, but involves the so-called internal vibrations of the ions and molecules present in the crystal. The magnitude of the frequency shifts are here of the same order as those observed with the corresponding vapours or liquids. It should be emphasised, however, that the crystal spectra are by no means generally identical with those of the gas or liquid and indeed

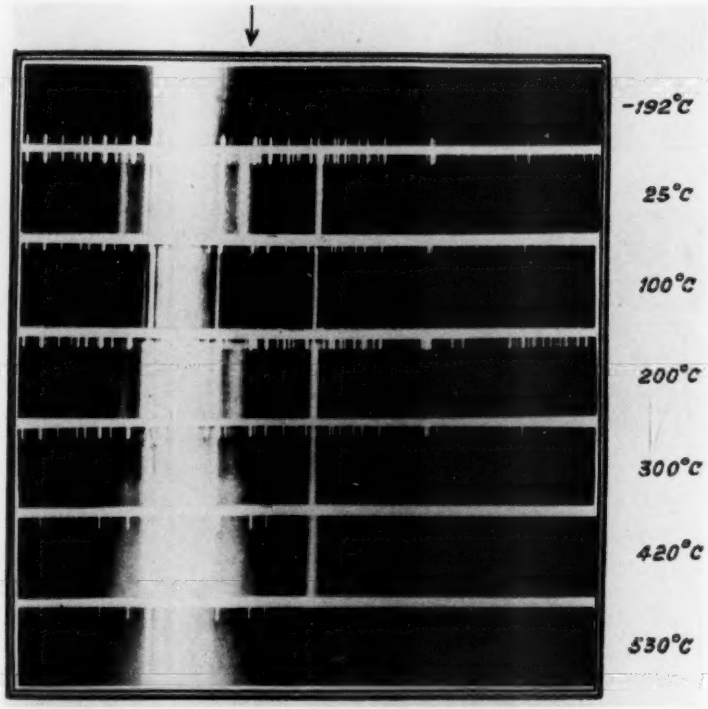

FIG. 2. Spectrum of light scattered by quartz at different temperatures.

usually differ from them in several respects. It should also be remarked that the study of light scattering in single crystals is capable of furnishing much more information than that of the same substance in the fluid state. It is evidently possible to record the spectra with the crystal placed and illuminated in different ways, to polarise the incident light in different azimuths, as also to analyse the scattered light. Numerous

spectra may be obtained in this way, and they often exhibit very striking differences, evidently connected with the orientation and optical anisotropy of the vibrating units and the geometry of their modes of vibration. Various methods are now available for growing large single crystals suitable

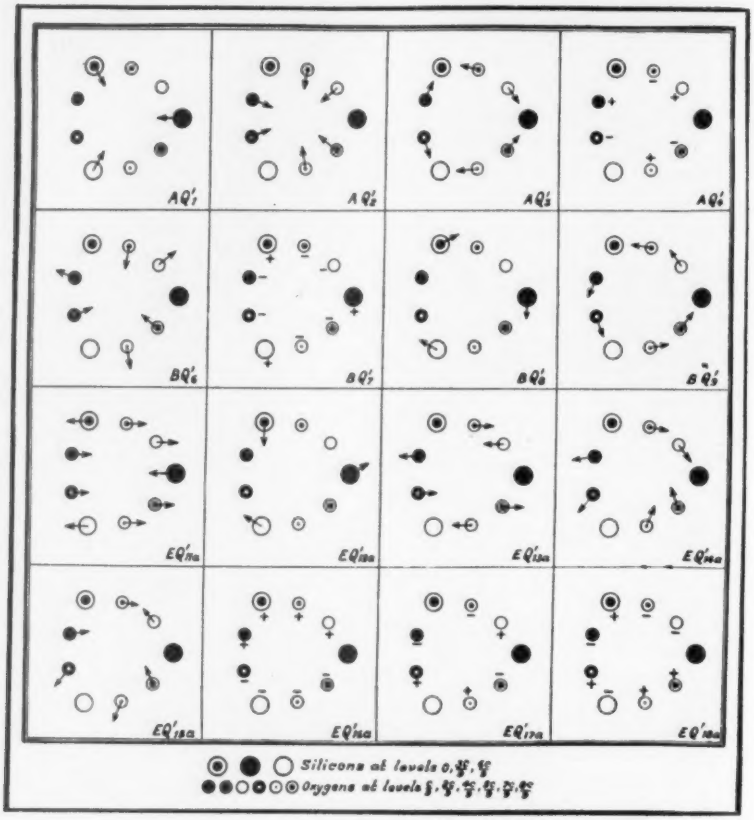

FIG. 3. Modes of vibration of the lattice in quartz.

for such investigations. As an example of work of this kind, a recent investigation on single crystals of naphthalene may be quoted.[10]

The results of such experimental studies may be correlated with the known crystal structures and enable us in many cases

[10] T. N. K. Nedungadi, *Ibid.*, 13, 161 (1941).

to identify the types of lattice vibration which give rise to the observed frequency shifts.[11] Perhaps the most exhaustive recent study of the kind which has been made is that with quartz.[12] A satisfactory explanation has been given of the spectroscopic behaviour of this crystal in the infra-red region, as also of its thermal properties. The well-known transformation in the crystal structure of quartz from the α-form to the β-form which occurs at 573° C. appears from this investigation to be a necessary consequence of the increasing amplitude of the symmetrical modes of vibration of the crystal lattice in the low-temperature form.

It is thus evident that the study of light scattering in crystals is a gateway to fundamental knowledge of the highest value regarding the solid state.

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[11] S. Bhagavantam, *Ibid.*, **9**, 224 (1939).

[12] B. D. Saksena, *Ibid.*, **12**, 93 (1940).

Resins for Purity.—According to the Industrial Bulletin of Arthur D. Little, Inc., Number 168, water equivalent to distilled in purity but produced without heating is reported to be the product of synthetic resin treatment. The resins for this treatment are of two types, the polyhydric phenol-formaldehyde type used for changing a calcium chloride water impurity, for instance, to hydrochloric acid by replacing the calcium with hydrogen, and the amine-formaldehyde type which removes the acids themselves. As "base exchange" media substituting one type of water impurity for another of less injurious type, the polyhydric phenolic resins promise improvements over other materials, but the amine-formaldehyde resins, used with the phenolics, offer an entirely new method of complete water purification. Hydrogen is available in the resin's hydroxyl group which readily goes into solution to replace calcium or sodium ions and forms acids, or, if desired the resin may be reacted with sodium and will then replace calcium or magnesium impurities with sodium. The general dependability of the phenolic resins is said to be superior to that of previous softening media; they are reportedly physically more stable, operate over a wider range of acid concentration and are significantly faster in action. However, save for the fortunate instance where carbonate forms one of the impurities and can be removed as carbon dioxide gas after treatment there is no actual removal of dissolved materials from the water. Complete removal is the function of the amine-formaldehyde resins, acting on the acids previously produced by phenolic-resin treatment. The theory of this removal is not yet entirely clear, but is believed to include both surface adsorption and reaction of the acids with the amine groups of the resin. Thus a water containing calcium chloride, for instance, as an impurity could have calcium replaced by hydrogen to form hydrochloric acid by treatment with the phenolic resin and then have the hydrochloric acid removed bodily by the amine resin to yield essentially "distilled" water. Just as the phenolic resins can be regenerated by an acid solution after exhaustion, the amine resins can be regenerated by an alkaline salt solution.

R. H. O.

THE NEW RADIO FREEDOM.*

BY

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A wall which has stood for years across the line of march of radio has been broken down. We look toward a new horizon and envision a new freedom of action. For the wall which has fallen is the belief in the minds of men that nothing could be done about the problem of the "static" and the cause of the removal of this wall is the discovery of a new principle in electric signaling.[1]

We now see clearly that the way to free ourselves from the effects of the various natural and man-made electrical disturbances which bedevil the present system of radio is to transmit waves whose characteristics differ in kind from those of the disturbances so that it becomes possible to distinguish at the receiver between the signaling and the unwanted kinds of waves. We see not only a freedom from the distressing noises which are only too familiar to us all, but freedom from what the engineer refers to as distortion and cross-modulation resulting in unnatural reproduction of the tones of music and the human voice. Here also the new principle applies, removing the main sources of this trouble and giving us a realism which can, on certain types of broadcast programs, be very startling, indeed.

The application of the principle to the interconnection of broadcasting stations by radio relay will free us from the limitations of the existing wire line system which is now in use and will extend service into regions where economics and physical obstacles do not now permit it to go. The advent of an "all radio" broadcasting system is not too far away. Various

* Read at the Medal Day Meeting, Wednesday, May 21, 1941.

[1] A method of reducing disturbances in radio signaling by a system of Frequency Modulation. *Proceedings Institute of Radio Engineers*, May 1936.

applications in the field of communications for aircraft, civil emergency and the military services are now being made.

The social and political aspects are taking form, for by a combination of a curious property of the new system [2] and the propagation characteristics of a hitherto unused part of the radio spectrum within which the system is now operating it becomes possible to set up many times the present number of broadcast stations. A "place on the air" hitherto denied them now becomes available for our educational and denominational institutions. Space is also available for stations for every town and city in the country and the increase in the number of channels of communication to the listening public and the attendant problems raised thereby forecasts re-examination of past legislative acts to determine their applicability to and bearing on our freedom of expression.

As we look into the future all this can be clearly seen; beyond lie the parts less clearly visible, perhaps so obscured as to be in the realm of prophecy. Precisely here is the time to look backward; to study the teachings of the history of the art, to observe the effects of the introduction of each new principle, and above all, to compare the prophecies, (or the failure to prophesy) with what actually came to pass.

The outstanding examples are not hard to find. Turning to the early days of Marconi, we see him transmitting a distance of a few miles with the waves of Hertz, limited, as those who understood electromagnetic theory were not slow to point out, by the same laws as those which governed the transmission of light. Who could foresee that in future experiments he was to elevate one of the elements of the Hertz oscillator and ground the other, thereby attaching the waves to the surface of the earth so that the barrier of the horizon was to disappear? And who, even after the principle of Marconi's discovery became known foresaw how far the art would develop before it came upon another of the great barriers which was to check its progress for a time?

This barrier lay in the fact that the energy which created the signal in the receiving system was limited to that actually transmitted through space from the sending station. Often-

[2] The ability to reject the weaker of two signals on the same channel.

times these signals were so faint in the then universally used telephone head set as to become discernible only through the holding of ones breath, an experience which was an every day occurrence to the experimenter of those times. The finding of a method of causing the received signal to release and to control locally created energy in any required amount some fifteen years after Marconi's great discovery broke down the second barrier. This ushered in the vacuum tube or modern radio era, which was to bring transoceanic communication, a practical radio telephone, and finally broadcasting in its wake. Only the merest part of the vast development to come was forecast, and there was little appreciation that this discovery was to open up an era of inventive progress the like of which the radio art had never seen.

Who was to foresee that some dozen years later, when the art had settled down to the transmission of its overseas communication with waves many miles in length, confident that by the use of these long waves it had overcome one of its major obstacles (the inability of shorter waves to span the oceans in daylight), that a miraculous discovery was to overturn every principle of propagation the art believed in. For, by the utilization of waves shorter than any which had heretofore been employed, infinitely better daylight transmission was to be obtained over greater distances than the long waves ever gave, in fact, to the ends of the earth.

Looking backward over these and other examples of the failure of the prophets to foresee what was to come leaves one with a source of wonderment at their lack of vision until one reflects that, after all, theirs was but the judgment of mortal men. So in endeavoring to appraise the present situation and in seeking to outline the extent of our travels in these newly opened fields before the next great barrier is encountered, ought we not to make our approach with profound distrust of the value of that wisdom and vision which it pleases us to think we possess?

It seems to me that he who fails to learn the lessons of the past, who fails to see that "we look backward as in the glare of a searchlight and forward through an impenetrable fog" and prefers instead to trust his present fleeting vision of what

he thinks he sees is bound to misjudge the future. Would it not be better, and I call this particularly to the attention of those who are to see for the first time the results that follow inevitably from the application of new principles to an art, to be guided by the words of Owen Young spoken many years ago, "What gives me confidence in the future of radio are the things we do not know about it."

THE RADIOSONDE: THE STRATOSPHERE LABORATORY.

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ABSTRACT.

The radiosonde, the most recently developed tool for use in the investigation of phenomena in the upper atmosphere, is described. The various merits and disadvantages of the three systems now in use for the transmission of physical data from the stratosphere are reviewed. In a discussion of present-day radiosonde technique are included descriptions of transmitters, receivers, meteorological and other observing instruments, and ballooning methods. Their application to the study of cosmic rays is given as a typical illustration of their usefulness in fields other than meteorological. A new formula for the upward velocity of a flight in terms of its free lift is developed, which shows that the observed constant rate of ascent of pilot type balloons is fortuitous, depending on a particular range of values of the Reynold's Number of the balloons.

INTRODUCTION.

The past decade has seen great advances in the means for exploring the earth's upper atmosphere, principally because workers in more and more fields of science have become interested in conditions there from their particular points of view. The meterologist is the one most concerned with exploration of the stratosphere, since its outstanding properties fall within his domain. He studies its pressure, temperature, humidity, wind velocity, cloud heights and thicknesses. However, he is by no means the only scientist who wishes data from these regions. Valuable information can be gained there concerning the light intensity in the visible and invisible parts of the electromagnetic spectrum and especially the ultraviolet content of sunlight; electrical conductivity of the air, and the atmospheric potential gradients; distribution of cosmic ray intensities; radio wave propagation; ozone dis-

tribution; transmission of dust, spores and bacteria; these are the more important present-day fields for investigation. Consequently a good deal of effort has been expended in devising methods for gaining this knowledge.

There are several ways in which instruments suitable for measurement of the desired data can be sent aloft. The most primitive of these is the kite, which in the past has provided the simplest means of raising instruments from the ground. Although its possible altitudes are naturally quite limited, it was for many years standard meteorological equipment, and served, in Benjamin Franklin's hands, to provide new information in electrostatics. But with the advent of the airplane, with its much greater range and flexibility, kites fell into disuse. The airplane could fly in calm weather when kites were useless, could go to any desired point, and bring back information on weather conditions. However, ordinary airplanes could not fly higher than about ten kilometers (roughly 32,000 feet), hardly to the base of the stratosphere, and scientists had to find a means of carrying their instruments to greater altitudes. The balloon seemed to be the only possible solution; consequently, efforts were turned in that direction.

One way of reaching the stratosphere was to build sealed gondolas beneath enormous balloons (Fig. 1), so that the men within could live at the heights which were attained: 22 kilometers, where the atmospheric pressure falls to 4 cms of mercury. But this method was so prohibitively expensive that only a few such ascents have ever been made. The remaining possibility is unmanned balloons carrying recording instruments, which can be built cheaply and lightly and thus rise to very great heights, of the order of 30 kilometers. These have been used extensively since the beginning of this century.

In the last decade a further refinement of the small unmanned balloon method has appeared: the radiosonde, an apparatus weighing only a few pounds, consisting of observational instruments and a radio transmitter which sends back to the observer the data as they are collected. It has two great advantages over the older method of recording: first, the desired information is recorded on the ground at the same instant that it is gathered in the upper atmosphere, and

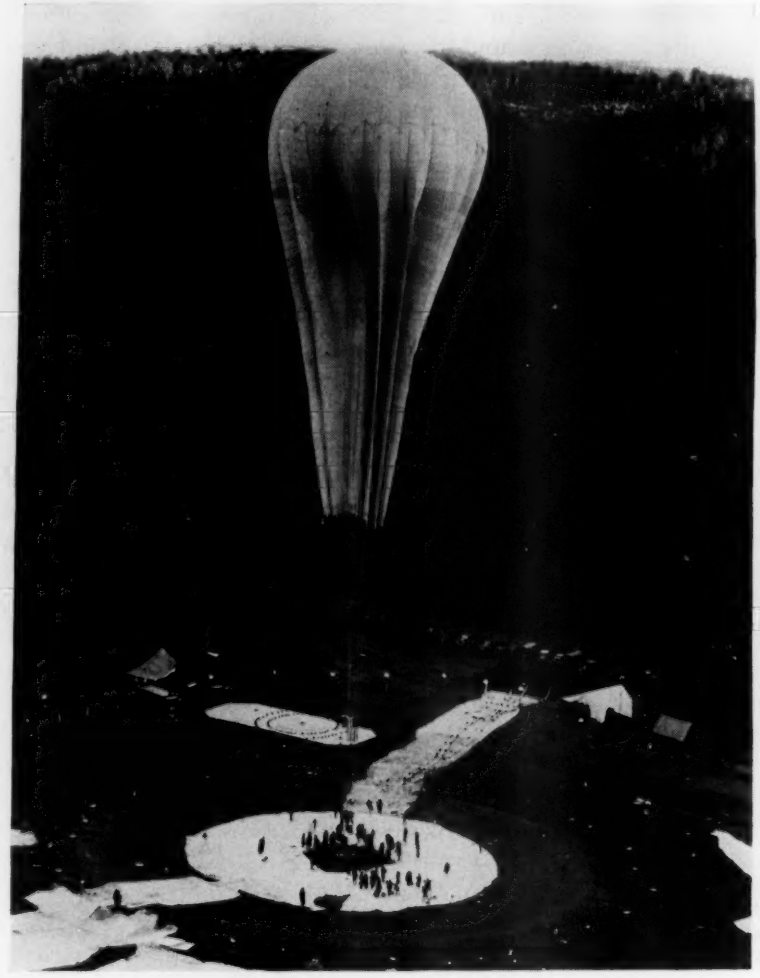


FIG. 1. The Explorer II, used in the National Geographic-U. S. Army Air Corps stratosphere flight in November 1935. This manned balloon reached an altitude of 74,000 feet. The gondola was sealed at about 17,000 feet in order to maintain air pressure for the observers. The balloon carried instruments for measuring the ultraviolet content of sunlight, atmospheric electricity, the usual meteorological variables, cosmic rays, and had special equipment for obtaining air samples, for collecting spores, for photographic work, and for several other studies. Radio was used only as a means of communication. Photograph Copyright, National Geographic Society. Reproduced from *The National Geographic Magazine* with special permission.

second, recovery of the apparatus is therefore unnecessary. Without radio, in order to obtain the desired data, one had to wait until the instruments were found and returned, with a chance that they would not be found at all. Thus it is not surprising that almost all studies in the upper air made today are carried out by means of the radiosonde.

GENERAL REQUIREMENTS OF RADIOSONDES.

Let us consider some of the general requirements which all types of radiosondes should fulfill, in order best to carry out their functions.

1. The cost of these flights must compare favorably with that of other means of reaching the upper atmosphere. We must assume that a radiosonde, like any other unmanned-balloon-carried equipment, is to be used but once, since the chances of its return for further use are usually small. Hence the cost per flight should be low—the lower the better, for then more flights can be made for a given outlay. This not only requires that the instruments themselves be inexpensive, but also that they be light in weight in order to reduce the cost of the lifting balloons and hydrogen. Receiving equipment on the ground, though not as important in this respect, should also be relatively inexpensive.

2. The radiosonde must be able to transmit its data with reasonable accuracy. This requirement applies, of course, not only to the observing instruments, but also to the mechanism whereby the data are converted into intelligible radio signals. If transmission of observations is not continuous, it should be frequent enough to give an accurate picture of the conditions under investigation. In addition, the system used should be capable of transmitting any reasonable number of variables.

3. The apparatus must be dependable. Since repairs are not possible after take-off, the chances of breakdown must be reduced to a minimum. But more important, it must be so constructed that gradual changes which would introduce unsuspected errors in the observations will not occur. Hence simplicity in construction and operation is a very definite asset.

4. At the ground station the system should record the observations, preferably automatically, eliminating the human factor as far as possible.

5. Total weight must be kept low in order to attain the highest altitudes. Since much of the weight consists of batteries used to power the transmitter, any system emitting interrupted signals is very desirable as it will require less power and hence fewer batteries. However, when directional antenna arrays to locate the radiosonde are used, continuous emission is almost necessary, and this advantage is lost.

6. Finally, in locations where the chances of recovery are good, the instrument must be constructed with ruggedness sufficient to withstand the shock of landing.

TYPES OF RADIOSONDES.

With these general requirements in mind, we can analyze the characteristics of the various existing types of radiosondes from the point of view of their comparative merits. First, however, it is interesting to review briefly the early history [1] of radiometeorography, going back as far as 1921 when Herath in Germany first experimented with a crude spark transmitter attached to a balloon. His attempts were unsuccessful, however, since the emitted signals were too weak to be heard at any distance. In 1923 Blair of the U. S. Army Signal Corps repeated Herath's tests, and was able to track the flight for 20 minutes to a height of 3.5 kilometers. It was not until 1927 that vacuum tube transmitters were employed, by Idrac and Bureau of France who thus found it possible to follow their apparatus up to the stratosphere. The Signal Corps was quick to recognize this new application, for in the following year they repeated the Frenchmen's flight with a much improved and lightened instrument. Finally in January, 1930, Moltchanoff in Russia succeeded in sending his radiometeorograph into the stratosphere. From then on, various other workers made rapid advances in improving radiosonde methods, notably Väisälä [2] in Finland, Thomas [3] in England, Duckert [4] in Germany, Diamond and Hinman,[5] Curtiss and Astin,[6] and Lange [7] in the United States. Their work resulted in the development of three different techniques, of which two have survived.

The three general procedures by which meteorological variables are converted into intelligible signals to be received at the ground station are:

1. Variation of the emission frequency of the radiosonde transmitter.

2. Variation of a modulation frequency impressed upon the fixed carrier frequency of the radiosonde transmitter.

3. Interruption of the transmitted signal.

A fourth possible method, variation of the intensity of emission, obviously has so many attendant difficulties that it has not been used.

Type 1: Variation of Emission Frequency.

Blair [1] (1924), and Duckert (1933), employed in their instruments temperature-sensitive elements which mechanically varied the capacity of the tank condenser of their transmitters, thus producing changes in the transmission frequencies proportional to the temperature change. Väisälä (1935) used the same method, but included elements which were sensitive to pressure and humidity, each controlling a separate condenser, which was connected in turn to the transmitter by a rotating switch energized by wind-paddles. Recording was effected by tuning the receiver to the varying emission frequency and noting the dial settings.

This system has the very great disadvantage that it requires an enormously wide frequency band, of the order of a megacycle, over which to operate. Even on short waves this width is enough to overlap many regular radio stations; it is certainly doubtful if permission would be granted by the Federal Communications Commission to use such an instrument.

Type 2: Variation of Modulation Frequency.

Diamond, Hinman, and Dunmore [5] (1937) were the first to apply this method and have developed it to a high degree. They employ a resistance-capacity relaxation oscillator to modulate their carrier frequency, using resistance elements which vary respectively with temperature, humidity, and light intensity (for measuring cloud thicknesses). By switching at previously calibrated steps from one resistance element

to another by means of a contact arm actuated by the atmospheric pressure, each variable could be transmitted in turn. The pressure determined the step, and thus by merely counting the steps, it could be ascertained in what pressure interval the instrument was located. The signals are recorded at the ground station by a graphical frequency meter which provides a complete record of the flight. The complete radiosonde was made very light, weighing less than a kilogram.

Thomas [3] (1938) independently worked out a variation of this principle, using inductance-capacitance audio oscillators and allowing each meteorological variable to give a separate audio note by mechanically changing the inductance value in its oscillator. The pitch of each note was calibrated to indicate the value of the variable, and the notes could be identified and separated by allowing each to vary only within assigned and non-overlapping limits. The several notes were superimposed and made to modulate the transmitted frequency. At the ground station beat frequencies were applied to each note to determine the values. Hence Thomas' method is the only one yielding truly continuous data for all variables. Measuring merely pressure and temperature, his radiosonde was very heavy, weighing 2.4 kilograms.

Diamond and Hinman's apparatus has been adopted by the U. S. Weather Bureau and has been made in large quantities. In the process of manufacture, difficulties inherent in its principle of operation, chiefly modulation frequency stability, have been almost completely eliminated, and as a result it fulfills all but one of our criteria. The cost of the receiving station is high since it requires an expensive graphical frequency meter. On the other hand, the radiosonde itself costs little, and is quite satisfactory, especially since the pressure switch is its only moving part.

Type 3: Interruption of the Transmitted Signal.

This class comprises the largest group, and uses the earliest and simplest principles. In 1877 Olland,[8] an instrument maker in Utrecht, devised the first telemeteorography system, on which all the following systems are based. In brief, it consisted of a moving contact arm (Fig. 2), driven by clockwork, which swept around a circle, successively making con-

nections with pointers whose positions around the circle were determined mechanically by pressure, temperature, and humidity respectively. The moving arm also swept across a fixed or reference pointer and then repeated the cycle. The result was a series of short pulses whose time intervals gave a measure of the desired quantities. With refinements, Moltchanoff [9] (1932), Lange (1935), Curtiss and Astin (1935), Maier and Wood [10] (1937), and others used this system for their radiosondes.

Slightly different means for obtaining an interrupted signal were employed by Idrac and Bureau [1] (1927), Moltchanoff [1]

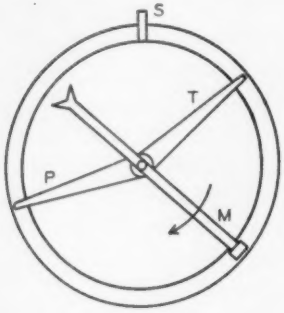


FIG. 2. The Olland principle of telemeteorography. The rotating pointer *M* sweeps with constant speed around the circle, successively making contact with the fixed stop *S* and the pointers *T* and *P*. The angular positions of *T* and *P* are controlled by the temperature and pressure. The resulting electrical signals are shown in Fig. 5.

(1928); and Insje and Soest [11] (1940). Bureau's instrument yielded its data by transmitting series of dots, the number of dots in each series giving the value of the variable. Moltchanoff's early apparatus and Insje's radiosonde sent out Morse code signals whose sequence changed with the measured conditions, and could thus be observed by ear at the ground station, without necessity of recording instruments. All of these methods, however, suffered from a lack of accuracy because of the insufficient range of these parameters.

The more successful applications of Olland's principle have completely satisfied our general requirements. The radiosondes can be built lightly and cheaply, and will transmit a

large number of variables. Although this method gives a series of discrete observations of each variable, the cycles can be made short enough to give about as accurate a picture as would a continuous record, of the regions the instrument is traversing. With very simple ground recording apparatus it will yield reliable data. It is not critical as to its circuit constants, which must withstand the severe temperature changes from sea level to the stratosphere. If it is desired to make radio directional measurements on the signals, the scheme of Maier and Wood [10] may be employed which reverses the transmitter keying and emits long signals broken by short intervals; in the normal method the transmitter is turned on for only a fraction of the time, permitting the use of light batteries. Finally, because of its cheapness and simplicity, it is the ideal system for the experimenter, desiring chiefly information other than meteorological, who sends off only occasional flights.

DISCUSSION.

1. Observation of Meteorological Variables.

As a rule, scientists in fields other than meteorology require, beside the variables in which they are interested, measurements of pressure to determine the altitude of the instrument, and of temperature of the apparatus itself to give some idea of corrections to be applied to the data because of instrumental temperature coefficient. Thus the problem of constructing adequate barothermographs is simplified, since the temperature-sensitive element need not to be arranged to give the true outside reading. Various laboratories have their own solutions to this particular problem, and one will be described here: the instrument developed at the Bartol Research Foundation in connection with studies of cosmic rays at high altitudes.

The Bartol radiobarograph [12] (Figs. 3 and 4), operates on the Olland principle, and employs a small electric motor to turn a bakelite disk in which is imbedded a platinum contact strip, electrically connected to the motor frame. A wire, fixed above the rotating disk and insulated from the motor frame, makes contact with the platinum strip once per revolution. In this manner a reference signal is provided. Two

other insulated wires also touch the surface of the disk. As the disk revolves, the platinum strip makes contact with the reference wire and then with these two in succession. These two wires are so mounted that their positions around the axis

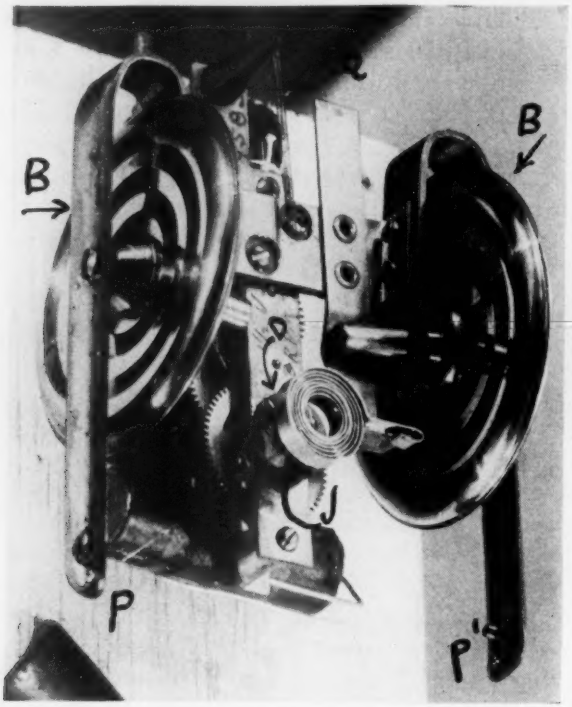


FIG. 3. Photograph of the Bartol radiobarograph, operating on the Olland principle. The wire suspension *PJQP'* communicates the motion of the expanding bellows *B* as the atmospheric pressure decreases, to the contact wire touching the rotating disk *D*. Thermograph spiral is directly above disk *D*, with its contact wire attached to its free end and touching the disk also. Small electric motor below rotates the disk through the train of gears.

of rotation of the disk are controlled by pressure and temperature respectively. Therefore, if the disk rotates uniformly, the time between the closing of the reference and the temperature-controlled wire contacts is a measure of the temperature, and similarly for the pressure. The three wires are connected together and key the radiosonde transmitter.

A cycle of three signals, identical to that of Olland's original system (Fig. 5), is thus produced. It will be seen that the time intervals between signals are dependent on motor speed. The interpretation of the signals may be made independent of motor speed by expressing the pressure reading as a ratio between two time intervals, namely that between the closing

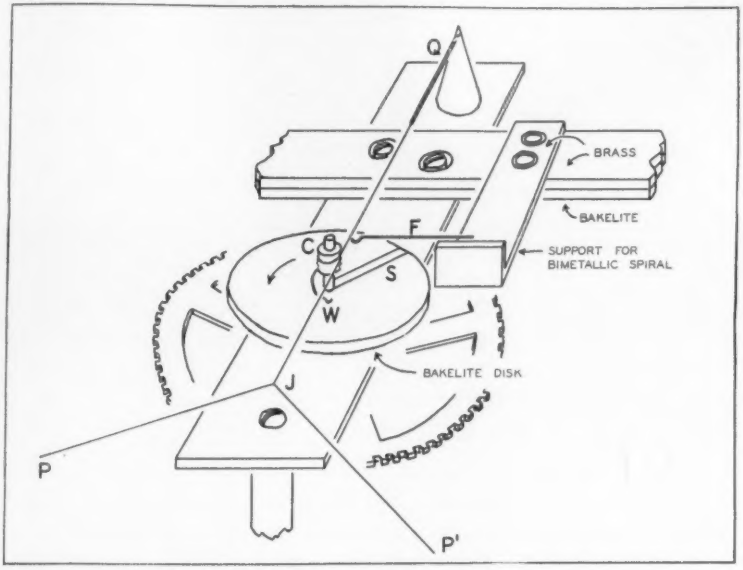


FIG. 4. Detail of contacting system of the Bartol radiobarograph. *S* is the platinum contact strip grounded to the motor frame and embedded in the rotating disk. The pressure contact wire *W* is fixed to the collar *C*, which in turn floats freely on the central shaft of the disk. The angular position of *C* is controlled by the pressure through the suspension *PJQP'*. *F* is the fixed reference contact wire. Temperature element not shown.

of the reference and pressure contacts, and that between two successive reference signals. This ratio therefore determines the angular position of the pressure contact wire with reference to the fixed wire. Further, since the platinum strip is of uniform width, the duration of contact will depend on the distance of the particular wire from the disk's axis. This allows each signal to have a distinctive length for easy identification (see Fig. 5).

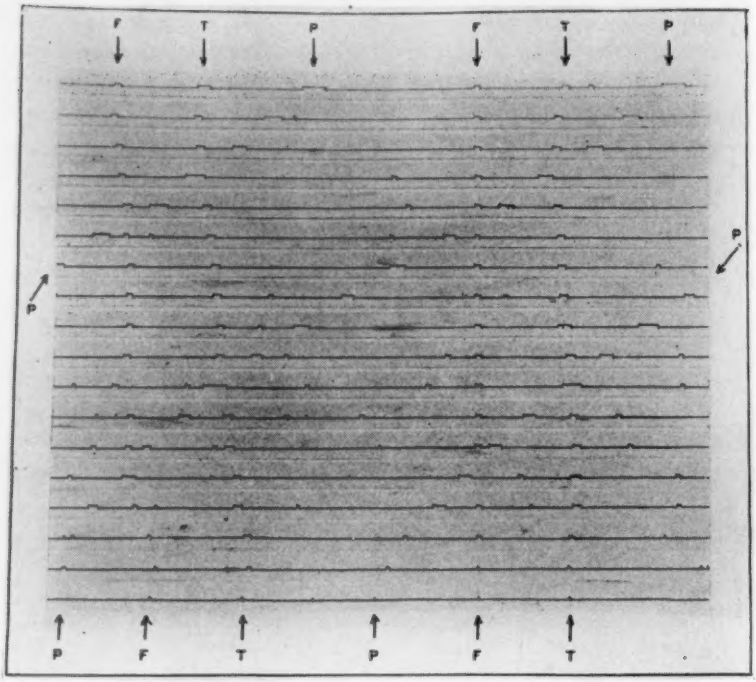


FIG. 5. Photograph of sections of original tape record from a cosmic ray flight made at the Bartol Foundation May 28, 1938. Each strip represents two Olland cycles, selected from the tape record at four-minute intervals. The top strip was recorded at take-off, with succeeding strips placed in order below it. The fixed reference marks are denoted by *F*, the temperature signals by *T*, and the pressure by *P*; all other signals indicate the arrival of cosmic rays, each mark representing the passage of 25 cosmic rays. The linear distance *F–F* in each strip represents one Olland cycle; the pressure is measured by the ratio of this distance to the distance *F–P*. Small changes in barograph motor speed are indicated by the varying lengths of *F–F*. Temperature (inside the cellophane housing of the instrument) remained almost constant. The flight ascended steadily, as shown by the progression of the pressure signals to the left, and was still rising when the transmission faded out. The cosmic ray intensity is measured by the number of impulses per unit length of tape; since the tape is pulled at a constant speed this gives the intensity per unit time. The record shows by the increased number of impulses in the lower strips the increase in the cosmic ray intensity with altitude.

The electric motor consists of a permanent magnet armature and a field coil. The current through the latter is broken periodically by a make-and-break contact operated by a cam on the motor shaft. It is therefore particularly simple to build, and will operate for days on a single small flashlight cell since its power requirements are only 2 milliamperes at $1\frac{1}{2}$ volts. The motor shaft is connected through a train of gears to the bakelite disk, normally operated at approximately 3 rpm, but which can be run at any desired speed. The addition of a simple friction governor consisting of a weight at the end of a spring, which impinges against the inner edge of a circular ring (see Fig. 9*B*) will cause the motor to run at a constant speed.

The pressure-sensitive element consists of ordinary aneroid capsules, the motion of which is communicated to the pressure contact by a suspension so arranged as to give increasing sensitivity at decreasing pressures (see Figs. 3 and 4). In this suspension there is little backlash or slippage, and so measurements can be made accurate to 1 mm of mercury pressure. The temperature-sensitive element consists of a bimetallic spiral coaxial with the disk, to one end of which the temperature contact wire is directly attached. The temperature sensitivity is proportional to the length of the bimetallic spiral, and in the present instrument was adjusted to yield values accurate to 1° C. The principal source of uncertainty of results given by this barothermograph lies in motor speed irregularities whose durations are short compared to the length of one cycle; slow regular changes introduce only second-order errors. This instrument has proved to be completely satisfactory during a period of over three years in which more than fifty were built and sent aloft. A modification of this instrument, designed with a view to simplicity in production, is shown in Fig. 9*A*. In this case the displacement of the barograph capsule is communicated directly to the moving contact system. This arrangement is easier to adjust and cheaper to build, but of course does not give such high precision in the pressure readings nor the increase of sensitivity with elevation. It is, however, adequate for certain purposes.

The Curtiss radiobarograph [6] and the Lange (Blue Hill) instrument [7] are both constructed similarly to that of the Bartol Foundation, except that Lange's apparatus employs clockwork to drive the Olland rotating contact. In his early models Curtiss experimented unsuccessfully with a watch drive, later abandoning this in favor of an electric motor. Work at the Blue Hill observatory has shown that good results can be obtained by using inexpensive alarm clocks whose hairsprings have been shortened and stiffened to run at about four times normal speed. In this way almost constant speed is obtained at all altitudes, as opposed to the electric motor whose speed increases with altitude because of the lessened windage retarding the armature. While slow rates of change of motor speed introduce only second-order errors in the measurements and are unimportant when recording is made on paper tape, constant speed is necessary when signals are to be plotted on a cylindrical chronograph record.

2. Radio Technique.[7c]

Operation of radiosondes is governed by regulations set forth by the Federal Communications Commission. Experimental automatic stations are permitted to transmit only on certain assigned frequency bands, must be licensed, and be under the supervision of an operator holding either a commercial license or a restricted radiotelephone permit. The latter license is issued to persons passing an examination in the electrical characteristics of the equipment they are to use, and the laws and regulations applying to them.

a. Carrier Frequency.—In general, the emission frequencies used by the various experimenters have covered a wide range; but the tendency has always been toward shorter wave-lengths because of their advantages of compactness of equipment and almost complete absence of reflected waves which produce fading. Early workers, limited by the radio apparatus then available, used wave-lengths of the order of 100 meters, but as improvements were made in commercial vacuum tubes this was brought down to wave-lengths as short as 1.3 meters, the limit with tubes now commercially available. At the present time, however, most experimenters use the region between 3 and 8 meters, since it combines the

advantages first mentioned and yet does not require special tubes. At these wave-lengths, type 30 receiving tubes may be used as oscillators, costing only 30 cents each; below 2 meters, acorn tubes at a cost of $3 must be employed. Another consideration is that of receivers: 1 to 10 meter sets on the market are cheap and reliable.

b. Transmitting Power.—8 meter waves (39 mc) are short enough so that they begin to approach the characteristics of light waves in that they are propagated in optical paths, are very little deflected in transmission, and are reflected but slightly from the ionosphere. Thus they are eminently suited to balloon work where transmitter and receiver are always connected by an uninterrupted path and hence allow the use of low power. Pear,[7c] assuming the normal maximum distance from radiosonde to receiving station to be not greater than 150 kilometers, and a field sensitivity of the receiver of $\frac{1}{4}$ microvolt per meter, has calculated that a radiated power of 30 milliwatts is sufficient for adequate reception. He therefore uses a transmitter emitting 0.1 watt to allow for any decrease in emission as the plate and filament batteries discharge. Diamond and Hinman use a power of 0.2 watt, while other experimenters, applying a larger safety factor, employ radiation up to 2 watts. It is apparent from these figures, then, that power of more than 1 watt is unnecessary, and anything greater than this simply increases the weight of the flight.

Owing to the straight-line propagation of the waves, it will be clear that no signals will be heard when the balloon drops below the horizon of the receiving station. So sharp is this cut-off that, since the altitude of the balloon is known from the pressure signals, fairly accurate estimates of the distance of the radiosonde can be made as it drops below the horizon. The relation is given by

$$D = k\sqrt{h},$$

where h, the altitude of signal cutoff, is in feet and D is in miles. The constant k, of the order of 1.25, depends on the height of the receiving station, and is best determined experimentally.

c. Transmitting Circuit.—Five standard oscillator circuits have been used in radiosonde work: the Hartley, Colpitts, and tuned-plate tuned-grid operating with one tube; and two push-pull two-tube circuits, one similar to the Colpitts and the other to the tuned plate and tuned grid. The most popular circuit by far is the tuned-plate tuned-grid with either a single tube or two in push-pull (Fig. 6), because of its

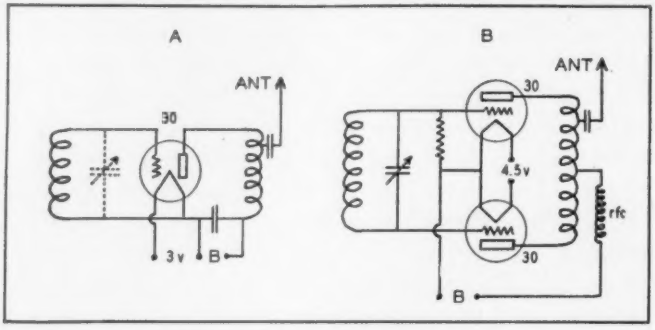


FIG. 6. Typical radiosonde transmitter circuits.

A. Single tube tuned-plate tuned-grid circuit. Grid tuning condenser optional; without it, circuit is tuned by adjusting grid-coil. The two coils are not inductively coupled. Feedback is through interelectrode capacitance. Ref. 7*c*.

B. Tuned-plate tuned-grid circuit in push-pull. Grid coil is placed inside plate coil. Ref. 6*e*.

inherent ease of control and better frequency stability. The usual tube is the inexpensive type 30, either alone or in pairs, except for the ultra high frequencies where the acorn type 955 is employed. Since the filament rating for the type 30 is 2 volts, the filaments of two such tubes in series may be operated on three flashlight cells. Often, however, the circuit using a single type 30 is powered by two cells in series which deliver a 50 per cent. overvoltage to the tube. This method increases the power output considerably without unduly increasing weight and at the same time shortens the life of the tube. This of course is no drawback since the tube is used at most for only a few hours. It has been found experimentally that this arrangement gives the greatest power-to-weight ratio and will continue to emit signals for 60 hours before the batteries discharge.

In the tuned-plate tuned-grid circuit, the ratio of capacitance to inductance in the grid tank is made fairly large to

ensure good frequency stability, since capacitance changes due to variations in temperature and humidity are small compared with inductance changes. In the plate tank, however, a low ratio is secured in order that possible detuning effects in the antenna system shall not throw the circuit out of oscillation.

Besides modulation of its waves, the oscillator may be keyed in three ways: by interrupting the plate lead, or the cathode lead, or by changing the grid bias. The first two methods are simple and positive, while the third has the added advantage of drawing practically no current at the key contacts. Modulation is achieved simply by coupling the modulating voltage capacitatively to the grid of the oscillator.

Antennae may be either voltage-fed or current-fed; in either case, the total length is about 5 per cent. less than a half wave-length. The current-fed antenna has a coil interposed in the center, to which the transmitter is inductively coupled, while the end of the voltage-fed antenna is either capacitatively coupled or directly connected to the oscillator plate coil. In general, the latter is the preferred type since it is not so subject to detuning due to the swinging of the radiosonde during flight. In the former type, the mass of the radiosonde is located at the center of the antenna and detuning occurs when the lower half swings out of line with the upper half. Coupling of the antenna to the oscillator must be adjusted by experiment, since too close coupling will throw the circuit out of oscillation, while if it is too loose, weak signals will result. With the voltage-fed antenna, closer coupling is achieved by moving the connection nearer to the plate.

d. Batteries.—Since flights as a rule do not last for more than a few hours, light weight batteries may be used throughout, even though the drain on them is comparatively high. Large size flashlight cells serve well as filament supplies, for they weigh only 40 grams and will deliver 50 milliamperes for 5 hours. Plate supplies, usually 90 volts, employ two batteries,* each weighing of the order of 150 grams and

* Batteries of light weight delivering 45 volts are available in the following models: Burgess V-30-FLN (123 grams) or W-30-FLN (295 grams), Eveready X-180 (65 grams) or No. 455, Mini-Max (215 grams) and General Dry Battery Co. V-30-M (165 gram) and others. The heavier batteries generally have greater current-supplying capacity and longer shelf-life.

delivering 65 milliampere-hours. Thus it will be seen that the batteries make up almost half of the weight in present-day radiosondes whose total weight averages 1 kilogram, and also that any saving in batteries is worth while. Some workers [2,10] have built their own lead plate storage batteries, but find that their power-weight ratios do not differ appreciably from those of the commercially available dry cells which are far more convenient. Light weight primary batteries have been built by Ramsey [23] and his collaborators and have been found to have useful properties as high voltage sources. Frequency stability is most affected by changes in the filament emission, occurring as its battery voltage decreases, and the filament supply must be adequate to keep the voltage reasonably constant for the duration of the flight. Due to the low plate current, plate voltages change very little and affect the frequency only slightly.

e. Receivers and Recorders.—Two types of receivers can be used, the superheterodyne and the superregenerative. While the superheterodyne is probably the most sensitive circuit available, the superregenerative possesses certain other advantages because of which it has most generally been used. This type of receiver is inexpensive, far less critical in its tuning, and easier to control at the frequencies employed. Further, it is not affected by noise during reception of a continuous signal, providing unique advantage for the Olland system. In its operation the set is so adjusted that a regeneration hiss is heard. A signal when received suppresses this hiss, at the same time rendering the set insensitive to other incoming radiation. This shut-off characteristic may be communicated to the recording system through a variety of circuits,[13] a typical one of which is shown in Fig. 7.

Receiving equipment for the method of variation of modulation frequency has also generally employed receivers of the superregenerative type. In addition, an amplifier and graphical frequency meter are necessary. This system of operation, however, does not permit of one great advantage enjoyed by the Olland type, namely inclusion in the recording circuit of comparatively long time-constants, of the order of a tenth of a second. This desensitizes the circuit to signals of dura-

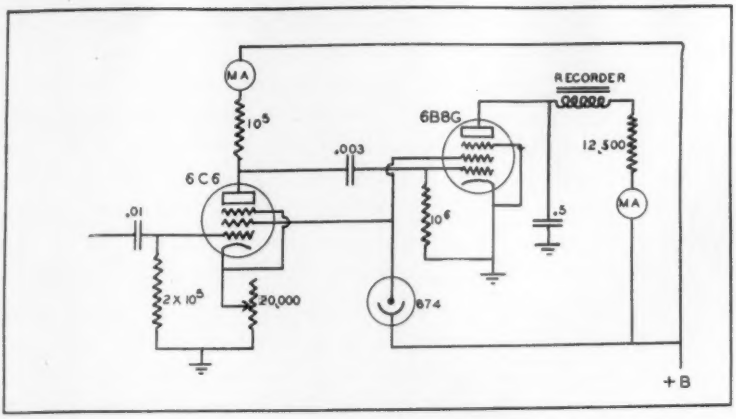


FIG. 7. Typical recording circuit. Input is coupled to output plate of super-regenerative receiver. Resistances in ohms, capacities in microfarads.

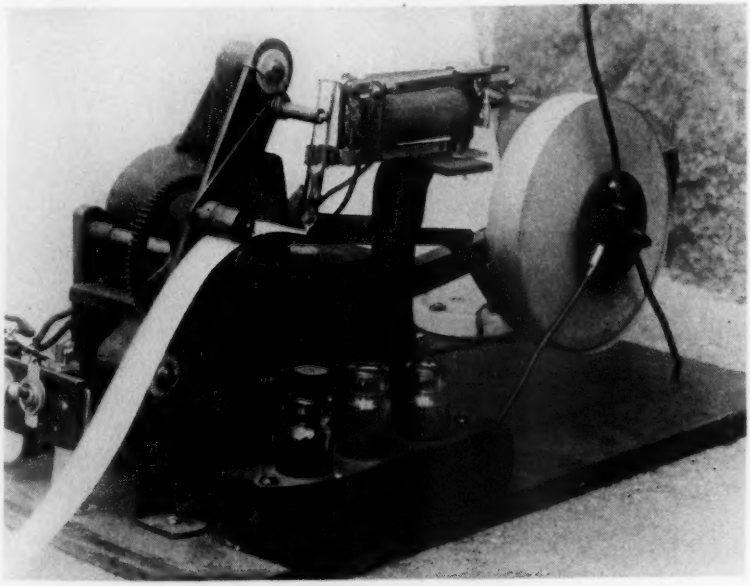


FIG. 8. Tape recorder. Paper tape is pulled by a constant speed electric phonograph motor. Glass pen with platinum tube tip is held in a clip attached to relay armature. Tape speed is about 1 meter per minute.

tion less than the time-constant, and hence brings the level of recorded noise practically to zero.

Recorders for the Olland system may consist of a magnetically operated pen which marks either a moving paper tape or a rotating paper-covered cylinder. A typical tape-recorder is shown in Fig. 8. Since a constant tape speed is desirable, the tape puller consists of a synchronous phonograph motor, operated directly on the AC power line. The pen consists of a small glass ink reservoir with a platinum tube writing-tip and is held by a spring clip to the armature of a Western Electric type G-26 telephone relay. Ordinary ticker tape is used for recording. The chief disadvantage of this system lies in the length of time necessary to measure the tape record.

This difficulty is overcome in the case of the paper-covered cylinder of the usual chronograph type. If in addition, the motor speed of the radiobarograph and the speed of the cylinder are made equal, then all the reference signals will lie along an element of the cylinder, allowing easy interpretation of the record when it is removed at the termination of the flight. Constant radiobarograph motor speed may be achieved by the use of a friction governor on the moving system. Such an arrangement is shown in Fig. 9*B*. In this case, since it is not possible to adjust the speed of the motor after takeoff, an adjustable-speed arrangement on the recording cylinder is most desirable.

Another type of recorder, used originally by Olland, employs a wide band of paper moving under a typewriter ribbon stretched transversely across it. Small marking wheels move steadily and successively along this ribbon, so arranged that but one wheel is above the paper at any instant. Their speed of travel is adjusted so that each wheel traverses the paper from edge to edge in the time of one complete Olland cycle. When a signal is applied to the recorder, the marking wheel then on the ribbon is depressed, leaving a short trace whose lateral position is the measure of the desired quantity. This instrument has the advantage of yielding a record which can be inspected and measured even while the flight is still in progress.

f. Receiving Antennæ and Directional Arrays.—Antennæ for short wave reception, on a single frequency range as is here required, are generally of the tuned dipole type, a half wave long and oriented vertically. This arrangement gives the greatest sensitivity and signal-to-noise ratio, enabling the observer to receive satisfactorily even at long distances the extremely weak radiation from the radiosonde.

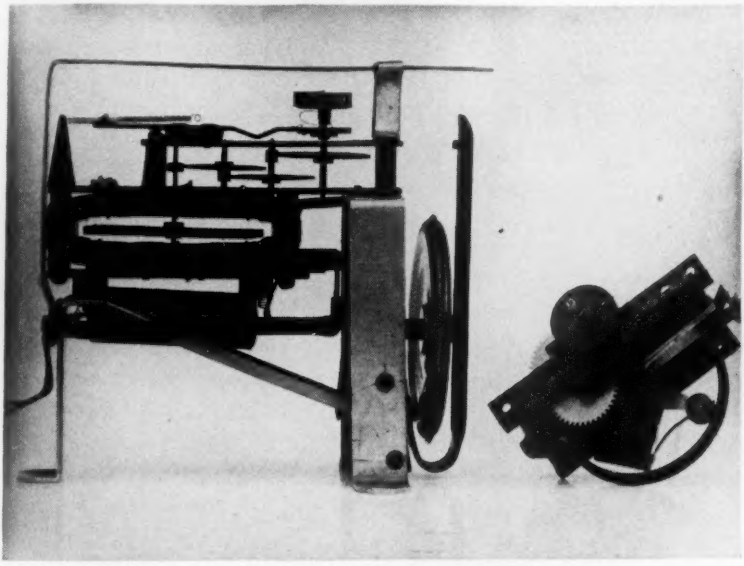


FIG. 9. *A*. Simple type of radiobarograph; motion of aneroid capsule communicated directly to contacting system; thermograph coil directly above contacts.

B. Constant-speed radiobarograph motor. Circular weight is shown, together with steel spring attaching it to bar magnet armature. The weight rubs against the inside of the ring when the motor runs; hence spring stiffness determines top speed. Note that this constant speed feature is not shown on the motor in *A*.

For radio directional observations, to determine the position of the radiosonde in the air and hence the wind direction and velocity at all elevations, a superregenerative receiver cannot be used because of its automatic volume control properties. For this purpose the superheterodyne set is more satisfactory, and several specially-designed circuits have been

described [14] which exhibit the necessary characteristics of stability in operation and sensitivity. The directive antenna arrays for use with these measurements are of two standard types, namely those employing combinations of half-wave elements to produce cancellation and reinforcement of the waves in the desired directions, and loop antennæ. In practice, the radiosonde is located either by the use of two receivers placed several miles apart and each measuring the azimuth bearing of the balloon, or by one receiver with an antenna which can be rotated to give both azimuth and zenith angles successively. The former method gives data sufficient for triangulation, while the latter yields the position when combined with the altitude as transmitted from the radiosonde.

(*To be continued in October issue.*)

GLASS: TODAY AND TOMORROW.[1]

BY

ALEXANDER SILVERMAN.

William Henry Hudson, the British novelist, created a fantasy in the eighties in his book "A Crystal Age." In the preface to this volume for a new edition of his works in 1906 he wrote, "In going through this book of mine after so many years, I am amused at the way it is colored by the little cults and crazes and modes of thought of the eighties of the last century. They were so important then, and now, if remembered at all, they appear so trivial."

Perhaps, some of the thoughts expressed in "Glass: Today and Tomorrow" may seem equally strange. Twenty-five years ago the content of such a lecture would probably have predicted an appreciable number of applications of glass which have since become realities. How many of the dreams of today will be the realities of tomorrow? Only time will tell.

If there is one common device which dates back thousands of years, it is the bottle. In Egypt it held perfume for the living, libations for the dead. In Rome it contained mercury and gradually in western Europe it became a container for beverages. The medicine bottle and the milk bottle evolved. The Egyptian bottle was a work of hours, the old hand-blown one a work of minutes. From the modern machine a bottle is born each second. There is little likelihood that the speed of production will increase much beyond the present limit. The quality of the bottle has changed. To prevent contamination of content, we can have a composition for almost every type required. But what of the bottle of tomorrow? Its composition may possibly be such that it will transmit one light radiation or another to its contents. A certain wave may favor fermentation and when the brew has reached

[1] A lecture delivered before the Franklin Institute, Philadelphia, Pa., December 18, 1940. Contribution No. 421 from the Department of Chemistry, University of Pittsburgh.

the state desired another wave may enter to sterilize the contents. In a large plant producing pharmaceuticals in our Mid-West, radiations are already employed to promote bacterial growth in selected cultures. In a famous porcelain factory in Europe rose-purple windows are installed in the room where the raw materials are mixed in a paste for casting. The rays which come through prevent the growth of molds which would spot the porcelain during firing.

Tomorrow's baby may drink from a combination bottle which transmits violet rays through one portion to sterilize the contents and absorbs through another portion to warm the milk. We already have glasses which transmit the short waves and colored glasses which heat up under the infra-red, certain greens becoming too hot to handle. Who will combine the two successfully for the new baby bottle?

What has been said for beverage and feeding bottles might be elaborated extensively. Imagine the entire dinner served in glass containers suitable for each type of dish and insuring just the right temperature for the contents, only making it necessary for the cook to throw the switches of radiating and heating units.

Windows at the beginning of the Christian era were crude cast panes. It required twelve centuries to yield a hand-blown window glass cylinder and four more to produce a rolled plate. Another two centuries passed before the cylinder machine was invented, and a little later continuous drawing and rolling processes came. Scientific and mechanical control have insured uniformity. Composition studies have brought variety. We have cased, or two-layer sheet. We enjoy not only the pane which lets light through and permits an undistorted image, but also the plate or sheet which will pass the health giving ultra-violet or the comforting heat rays. Should warmth not be desired, there is a plate glass which absorbs heat. In bulbs, one glass transmits the X-ray for examination or treatment of materials and men. Plates of another composition absorb these same rays to protect the operator who might otherwise be injured through exposure to them. Early X-ray absorbing glasses deteriorated, discolored. A new type which still insures the protection of men does not discolor.

Ordinary plate glass and mirrors are known to all. Plate glass in black and white and colors is now a material for construction. Near London there is an inn whose attractive exterior is black and white plate. Store fronts are constructed of plate glass in a variety of colors. A mural in a club may be red plate with relief silhouettes in black plate. A panel in a restaurant portrays a banana plantation as a colorful decoration. Glass ballustrades catch the eye, and mirrors lead the way to endless space. But critics say, "What glare!" For those who want less light, there are the somber tones, and on the 'morrow maple, oak, and ash may have to bow to panels born of sand and flame and not rich soil.

Laminated safety glass in the wind shield and car window are commonplace. Even one inch bullet resisting glass of several layers is known to many. One writer has christened it "transparent steel," but that is uncomplimentary for bullets which pass through steel, though they may chip the glass, are merely ricocheted. A newly developed laminated glass four and a half inches thick, for airplanes, has thus far resisted the passing of any projectile that could be fired at the flying pilot. What next? Will the fortress of the 'morrow be of glass, instead of steel and stone?

In tubes of glass a chemical vapor of one type or another, through excitation, forms a ray. Vibrations which sterilize serve not only the surgeon during an operation, but so sterilize meat that it may season at higher than refrigerating temperatures without deteriorating and go on the market in a shorter time, a product more tender and more tasty. Already, inferior grades of meat so treated are available at low rates in several American cities. Tomorrow, we may all enjoy a broiled round steak as tender and juicy as a filet for the present cost of a hamburger. Through sterilization and cold storage, supply and demand may be equalized to an extent where food supplies are continuously assured at modest prices.

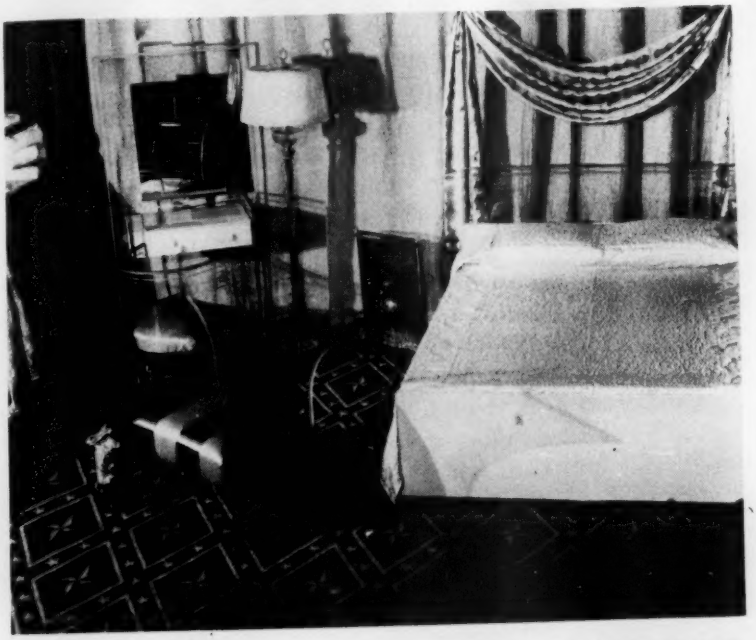
But is utility all? What of æsthetics? Should not the light which comes through glass please as well as serve? In the Glass House of the New York World's Fair pink tinted glass produced a pleasing glow, an appreciated contrast to that sallow tint from the ordinary greenish pane. Much furniture within this house was glass: the bed and dressing

table, bench, chairs; in the study the book cases and desk; in the living room the smoking stand, table and radio cabinet, and before the fire place a glass screen to stop the sparks; in the conservatory special glass to aid plant growth. All the glass was plate. Still very costly, a bit heavy, and breakable. But what will the future bring? The mood might want the warmth of red, the sunset glow of orange, the yellow of early spring, the green of summer lawn, the blue of northern sky, the cooling shade of wisteria. Why not let moods play freely in future homes? Years back Maude Adams, in staging a fairy tale, inquired "Can we produce any effect from sunrise to moonlight?" An affirmative answer to that fairyland question may be given in the home of tomorrow.

Again, today we live in light quite commonplace, and see and think in its terms. We admire a painting under a tungsten bulb or possibly a luminous tube. We may prefer a direct illumination in the home, an indirect, a bright, or a subdued one. But now we have a glass which leaves all black, and sends through rays that light in novel ways. The violet which passes and is not visible to the naked eye, or hardly so, may strike a dye or material which becomes luminous. Who knows? Tomorrow's citizen may at times prefer darkness, the better to enjoy things light. The dual effect of a daytime illumination and one for night may lend variety. The artist of tomorrow, going from light through shade to darkness, may envision that of which we do not even dream.

Already we enjoy the light produced by other light. In fluorescent tubes an incandescent vapor, faintly light, plays on a coating and, depending upon its chemical nature, yields tones from pure north sky to pastel pinks and blues and greens and yellows, even the sturdier oranges and reds. In-doors, we already have daylight from the bulb or tube. Variety or effect to suit every taste should come. Perhaps, the present lamp bulb will be as much an antique in years to come as the oil lamp of the past century is today. The carbon filament bulb is already unknown to the younger generation.

There was produced in France before the present war (World War II) a plate glass stove in which a metallized design fused in the glass so resisted the electric current that heat was radiated. It is attractive. Though still expensive,



it points a finger to the future. Imagine walls of glass with rich metallic patterns radiating warmth in winter. Or somewhat cooler floors with tiles, decorated with metals, which warm the feet. A floor, slightly warmed, produces added comfort. Such warmth would make it unnecessary to heat rooms to the temperature now required. Designed in harmony with the metallic decorations, glass walls might be perforated. Assuming a double glazing system for windows exposed to the out-doors to prevent sweating, the decorative wall pores could regulate humidity in winter and bring cool air in summer from an air conditioning system.

Now take a step from the general to the more specific. Perhaps, the dining room will have a table with a glass top where the place doilies are metallic designs so controlled that the dinner plate may be kept warm for certain courses. Beverages hot or cold may be served from attractively designed vacuum-walled cups or glasses. At breakfast the morning micro-film may project the news to a small glass placque beside the coffee cup. You will not even have to turn the pages. Before breakfast you will have stepped into your glass tub with its imbedded heating element set the night before so that your bath would be exactly right. You dried in a glass panelled room where some of the decorative panels shed health rays and the others warmth. At night, when the baby cries you will turn on the black light in the bedroom instead of a glaring bright light. You will immediately find your robe which glows under "black light" in the dark and you may follow a fluorescent line in the carpet directly to the crib. The idea of darkness with the utilization of rays to produce incited luminescence is not restricted to the home. Fluorescent carpets and dark lamps are already in use in the aisles of some of our theatres. Artistically designed carpets and drapes are every-day commodities.

In the classroom while illustrations are being projected on a screen instead of turning bright lights on and off fluorescent chalk will enable the lecturer to supplement the illustrations with diagrams on the blackboard. Students, using fluorescent panels or ink on a faintly luminous paper will record their notes in the darkened room.

In the field of optical glass, though the special light absorbing and transmitting glasses already mentioned may be called optical, we shall begin with the big lenses. It was considered a feat when Jena cast a hundred inch lens at the beginning of the century. The two hundred inch Corning reflector for Mount Palomar no longer produces a thrill. We are told that the moon will, with this reflecting lens, look as it would to the unaided eye at a distance of only twenty-five miles, and that if the earth were flat a sign on Broadway in New York would seem from Mount Palomar as it does ordinarily to the pedestrian on the other side of Broadway. Will we have larger reflectors? The press shortly after completion of the two hundred inch reflector mentioned a thousand inch disc as the next goal. Perhaps! That must depend either on higher railroad culverts (for the Palomar lens cleared the lowest by only a few inches) or an air transport; also, on the ability of men in fields other than glass to provide the foundation and supports for the giant. Chemical and physical science should prove capable of furnishing the glass and the annealed casting. Who knows what startling truths the distant worlds may yet bring man?

In small lenses we may say that varieties of refractive index depending on composition will probably take the lead. Already we are up to 1.7 and well towards 2.0. Studies better to overcome color fringes have born fruit and will bear more. There is not merely the question of light path, but also that of durability. The optical property is worthless unless we can preserve the host.

What of the eye? The vision is corrected more accurately than ever before. The composition and cutting of lenses, the mounting, make for greater comfort. Not wishing to wear the mounted lens, we have recourse to contact lenses which hug the eye-ball. The bifocal portion of the more ordinary lenses may be melted on or cut in. Cement is not necessary. Tomorrow? We may have lenses so constituted, ground and polished that the eye will see perfectly and gradually, everything from the close to the distant and in all directions. Accessory to glass and supported by it is Polaroid which cuts out glare on everything but polished metal and bright glass. It is used in goggles. In time such lenses may

become unnecessary. Windshields and windows may carry the eye protective film in a lamination and we may witness further surprises; in several dining cars double circular windows have already been installed whose polarizing films may be rotated to any angle and produce anything from full light to darkness. It is only a matter of time when this type of window will enter the office and the home, and displace the window shade and the Venetian blind. The cost? Idosulfate of quinine is still quite expensive. Production cost may drop. Less costly substitutes may appear. Going back to goggles, there are many types which cut off ultraviolet light or glare to any desired degree. Will the day come when very light duplex Polaroid lenses will cover the eye, one disc to be rotated to control transmitting intensity? Perhaps. Then we shall have the rays we want and any intensity to suit the will.

And now, to smaller things. In microscopes we magnify a thousand times and more. The correctness of image determines truth or its distortion. Improvement of composition is demanded for that tiny bead, the high-power objective. The ultra-microscope, the electron microscope, though their principles are independent, in part need the glass lens as an accessory. Will we go beyond the microbe, the colloidal particle, the large molecules? Will we see all molecules, and atoms, and even their parts?

Silica is a component of most glass batches. As pure quartz it is prized in the prism. Selected fragments may be melted in electric furnaces to transparent fused quartz. The optical properties of the fabricated product, namely, high conduction of ultra-violet, visible and infra-red radiation with its index of refraction and internal reflection make transparent fused quartz a promising material, when once produced at a low cost. As has been hinted for many years, when sand which is largely quartz containing some impurities can be purified cheaply and the cost of power brings transparent quartz down to the price of glass, we may send light through rods around corners and illuminate the various rooms of a building from one or a few lamp bulbs. Perhaps, we shall bring warmth from the tropics and carry light to the dark portions of the earth from those which are light. The

principle is already applied in small Christmas trees which carry light through glass rods to their candle-like tips from a single bulb in the base of the tree; also, in the costly synthetic plastics for ornamental household lighting.

Next think of filaments, for rods of glass so thin are like the spider's thread. In batting form, a mass but four inches thick insulates like a ten-foot concrete wall. Already glass wool is used in refrigerators, cars, ships, and building walls, where it keeps heat in or out as required and also prevents ingress of rodents and vermin. Farmers are using it as an insulating blanket on flower beds and as a band around trees to prevent insects from ascending and destroying foliage. With an adhesive, the wool filters air in conditioning systems. Tape, or ribbon, and cloth are used for electrical insulation, even fiberglass tubing around wire. Glass fiber alone or woven with silk is on the market in men's neckwear, and in attractive table cloths, bed spreads, and tapestry-like fabrics. Drapes and awnings are other possibilities, desirable because of their nonflammability. Will glass fabrics become desirable for wearing apparel? That remains to be seen. With a desirable composition and the right properties, it could happen. Of course, glass fiber is practically nonabsorbent and unlike cotton would refuse to take up perspiration. This very failure causes moisture to condense in glass wool used for insulation. It may be that cellular or bubble glass, full of air bubbles sealed in glass which moisture does not penetrate, will some day replace fiber glass for insulating and building purposes. Like the latter it is rodent and vermin proof.

But even that may join the past, for hollow glass tile both insulates and guards against the pests. While modern ventilation and air conditioning will be a part of every clean structure of the future, they do not preclude windows in glass hollow tile buildings. They merely stipulate that windows shall not open. The new double-pane windows also insulate and the polished plates pass the image without distortion. You do not like the glare through hollow tiles? Then order them in color. Or, you may prefer a tile with metalized interior or enamel decorations. Perhaps you will want the light both day and night. Then you may install the vacuum

tile which, like fluorescent tubes, lights up at the throwing of the switch.

And so we build and dream. The day may come when man will have "A Crystal Age." Now let glass speak:

I AM GLASS.[2]

I am created of the admixture of Earth's minerals formed by the alchemy of time.

I am born transformed in the blasting heat of fiery furnace.

In molten mass I am tediously fashioned by the hand of cunning Artisan—or fed into the maw of intricate machine.

I assume ten thousand hues of all the spectrum—either transparent, translucent or opaque—upon my maker's will.

I can masquerade as ruby—emerald—topaz—moonstone; and all the other priceless jewels of man.

But frivolous baubles are not my aspiration—I serve ten million purposes in as many different places, forms and ways.

My duties are unnumbered—infinite; pay heed to my utility:

I admit the Heavenly light to hovel, palace or cathedral, and yet repel cold winter's howling breath.

I faithfully project the light that warns great ships from shoal and concentrate the beams that guide swift vehicle through storm and gloom of night to bring the wayfarer safe home.

I visibly contain my master's food—his drink—and countless other of his commodities; protecting them in transport and in the mart and home.

I form the shell of glowing bulb and tube to diffuse his artificial light—and to disseminate his advertising.

I am the walls of his abode, his office and his factory—and objects of utility and art in each of these.

I reflect his image—and mark the effects of time upon his person—sometimes I flatter but more often am critically severe.

I correct his impaired sight and thus bestow enjoyment of the printed word—and all of Nature's beauties roundabout.

I magnify his minute, unseen enemies and thereby do I promote his health and happiness.

I form the gossamer thread from which is fashioned fine raiment—yet too the insulation of his dwelling.

I reveal to him the mysteries of his Universe—carrying his vision to the illimitable reaches of the outer stars.

[2] Copyrighted in 1940 by George J. Overmyer and reprinted with his permission.

Through me he learned to chart the Firmament—to plot the orbits of the Planets and predict the courses of the Comets and Eclipses.

This knowledge I unfold is but the pledge of vaster knowledge as—step by step—I lead him to unexplored, immeasurable spaces.

For I am older than the Pyramids yet newer than tomorrow's unborn dawn—withal the marks of time affect me not—for I am ageless and retain my lustrous beauty permanently.

Some of my tasks I have recounted—but this is only the beginning; for those who make me and adapt me to their uses, are men of vision—and together, as time unfolds, we will go far.

And so—in modesty I proclaim—I am Man's invaluable and versatile servant—I AM GLASS.

World's Largest Radio Laboratories to be Built by R.C.A. at Princeton, N. J.—Recently announced by David Sarnoff, President of R.C.A., these laboratories will be known as "R.C.A. Laboratories" and will be the headquarters for all research and original development work of R.C.A. and for its patent and licensing activities. The new organization is planned to promote the growth of radio as an art and industry, and to meet the expanding demands of national defense. A further purpose will be to facilitate the creation and development of new radio products and services which will provide new business and new employment for the post-war period. Under the impetus of emergencies intensive research creates new instrumentalities, and further research and development are necessary to adapt them to use by the public. Mr. Sarnoff said, "We believe that this step marks a milestone in the progress of radio. Such important fields as television, facsimile, electron optics, wave propagation and ultra-high frequencies open to radio a future even greater than its past. The developments in these fields will contribute to the creation of new industries and to the improvement of existing services."

R. H. O.

Population Leveling Off.—The number of deaths in the Nation increased slightly in the decade of the Thirties, not because of a higher death rate, but because there were more old people to die, said Dr. O. E. Baker of the U. S. Department of Agriculture, analyst of population developments likely to affect future markets for agricultural products. As a result of fewer births, the cessation of immigration, and more deaths, the annual increase of the Nation's population has declined from an average of nearly 1,700,000 a year during the decade of 1920–29 to less than 900,000 a year during 1930–39. Since about 1932 the number of births has not been sufficient to maintain permanently the population of the Nation. The 1940 Census revealed a deficit of about 4 per cent. The crest of population seems likely to be reached about 20 years hence.

R. H. O.

THE FRANKLIN INSTITUTE.

MEDAL DAY MEETING.

Medal Day at The Franklin Institute was inaugurated just fifteen years ago. Since that time, on the third Wednesday in May, scientists and laity have gathered together to do honor to men who have achieved distinction in their special fields.

The exercises for 1941 were held on Wednesday, May twenty-first. The meeting was called to order by the President, Dr. Philip C. Staples. He asked the Secretary, Dr. Henry Butler Allen, for a report of business. Dr. Allen having stated that other business had been set aside to give place to the award of medals, Dr. Staples announced that the meeting was really a report on the work of the Committee on Science and the Arts, and stated that the men who were the recipients of the various medals in the past were not always men of great national fame at the time they received medals here. The search of the Committee has been for men, younger men, who have begun in science and technology to find themselves in their positions in their fields—to find the springboard of their greater careers. Few of them were as we know them today but were men, modest in their claims, who were beginning to make their mark. The encouragement given to these men through awards is a service for which the Institute was founded: "the promotion of the mechanic arts and the dissemination of scientific knowledge."

Dr. Staples, after pointing out that we had some distinguished guests with us, called upon the sponsors to present the Medalists for their awards.

Presentation of Certificate of Merit.

To Charles William Akers, President, Breeko Corporation, Nashville, Tennessee.

Dr. Staples called upon Mr. Samuel Shoemaker, Sponsor.

Mr. Shoemaker: "Mr. President, the Board of Managers, upon recommendation of its Committee on Science and the Arts, has awarded a Certificate of Merit to Charles William Akers, President, Breeko Corporation, Nashville, Tennessee, 'in consideration of his invention of the Breeko Floor Block.' I present Mr. Akers to you for his award. . . ."

Dr. Staples: "Mr. Akers, we are glad to issue this Certificate in recognition of your very useful invention. We also want to express our thanks to you for traveling such a distance to be with us today."

PRESENTATION OF THE LONGSTRETH MEDAL.

To Benjamin James Wilson, Chief, Mechanical Division, Research Department, Leeds and Northrup Company, Philadelphia, Pennsylvania.

Dr. Staples recognized Dr. Barnes, Sponsor.

Dr. Barnes: "The Committee on Science and the Arts voted the recommendation of an Edward Longstreth Medal to Benjamin James Wilson, Chief, Mechanical Division, Research Department, Leeds and Northrup Company, Philadelphia, 'in consideration of his development of an integrating and recording flowmeter of high precision, embodying physical principles not hitherto used for this purpose.' Mr. President, the Board of Managers has accepted the Committee's recommendation. I present Mr. Wilson. . . ."

Dr. Staples: "Mr. Wilson, by power vested in me as President of The Franklin Institute, I present to you the Longstreth Medal. We are always pleased to have a fellow citizen among the recipients of our awards."

PRESENTATION OF THE WETHERILL MEDAL.

To Harold Stephen Black, Bell Telephone Laboratories, Incorporated, New York City.

The presiding officer called upon the next sponsor, Dr. W. R. Wright.

Dr. Wright: "Sir, it is my privilege to represent the Committee in presenting the gentleman to receive the John Price Wetherill Medal. The Board of Managers has accepted

the findings of its Committee and has taken the necessary action to award the medal to Harold Stephen Black, Bell Telephone Laboratories, Inc., New York City, 'in consideration of his work on amplifiers, especially his development of the negative feedback amplifier' . . . Mr. Black."

Dr. Staples: "Mr. Black, as President of The Franklin Institute I present to you our Wetherill Medal. As a member of the Bell Telephone family I offer you my heartiest congratulations."

PRESENTATION OF THE BROWN MEDAL.

To Willis Haviland Carrier, D.Eng., Chairman of the Board, Carrier Corporation, Syracuse, New York.

Dr. Staples called upon Professor C. M. Gay, Sponsor.

Professor Gay: "In presenting the next gentleman, I wish to point out, Mr. Chairman, that the Frank P. Brown Medal was founded only in 1938 and is conferred 'for invention and discovery in the building and allied industries.' It is given today for the first time and will be received by Willis Haviland Carrier, D.Eng., Chairman of the Board of the Carrier Corporation, Syracuse, New York, 'in recognition of his outstanding achievements in the field of heating, ventilation and air conditioning.' . . . Dr. Carrier."

Dr. Staples: "Dr. Carrier, you have indeed played an important part in our modern civilization! You have added to the comfort of daily living in the home, in the office, in traveling, and by your prowess have quickened the imagination of others, so that your ideas are applied to ever expanding uses. We are glad to welcome you here today and to bestow this honor upon you—the first to receive it."

Dr. Carrier thanked the President and the Institute for this honor.

PRESENTATION OF THE CLARK MEDAL.

To Raymond Mower Conner, Director, Testing Laboratories, American Gas Association, Cleveland, Ohio.

Dr. Staples: I now call upon Mr. Fulweiler.

Mr. Fulweiler: "Mr. President, I have the honor to present the recipient of the Walton Clark Medal, who has been

selected for this award, 'in consideration of his outstanding service to the gas industry as organizer and director of the work of the American Gas Association Testing Laboratories, which has resulted in important developments in performance, durability and safety of gas appliances and in fundamental research work of great value.' . . . Mr. Raymond Mower Conner, Director, Testing Laboratories, American Gas Association."

Dr. Staples: "Mr. Conner, you have made important contributions to your field of work. It gives me much pleasure to present our Clark Medal to you. It is one of our most prized awards and if you will look back through the list of those who have received it before you, you will agree, I am sure, that you are in good company."

PRESENTATION OF THE LEVY MEDAL.

To John Moyes Lessells and Charles Winters MacGregor, Ph.D., both Associate Professors in the Department of Mechanical Engineering, Massachusetts Institute of Technology.

Dr. Staples: May we hear from Dr. Bazzoni.

Dr. Bazzoni: "The Levy Medal is awarded each year by The Franklin Institute to the author or authors of a paper selected from those published during the year in the Journal of the Institute which, in the opinion of the Committee on Science and the Arts, possesses especial merit. In making an award of this medal it is further required that preference be given to a paper describing the author's experimental and theoretical researches in a subject of fundamental importance. The paper selected for the Levy award this year, entitled 'Combined Stress Experiments on a Nickel-Chrome-Molybdenum Steel', meets the specified conditions in a satisfying manner.

"It was necessary for the authors of this paper to devise new and special instruments in order to carry out their experimental studies. The results obtained were of a kind never before rendered available to engineering designers involving measurements of combined torsional and tensional stresses. The paper included, furthermore, a theoretical analysis showing how the results fit into the framework of existing theories.

It was the expressed opinion of several experts in the fields of metallurgy and of engineering design, to whom this work was referred, that it is of substantial value and that it has a timely application in the solution of problems vital to the national defense and especially in connection with the airplane industry.

"In view of these facts, Mr. President, it gives me particular pleasure to present to you, as Levy Medalists for the year 1940, the authors of the paper "Combined Stress Experiments on a Nickel-Chrome-Molybdenum Steel" which appeared in the August 1940 issue of the Journal of the Institute. . . . Professor John Moyes Lessells and Professor Charles Winters MacGregor, both of the Massachusetts Institute of Technology."

Dr. Staples: "Our JOURNAL has its deserved reputation alone because of the papers published in it. The Committee has selected your contribution as the most fitted to receive the Levy Medal, in accordance with the citation just read. I have much pleasure in presenting it to you."

PRESENTATION OF THE POTTS MEDAL.

To Harold Eugene Edgerton, D.Sc., Associate Professor of Electrical Engineering, Massachusetts Institute of Technology.

Dr. Staples: The next sponsor, Mr. Tabor.

Mr. Tabor: "Mr. President, I sponsor the award of the Howard N. Potts Medal, given for 'distinguished work in science or the arts; important development of previous basic discoveries; inventions or products of superior excellence or utilizing important principles.' The Committee has recommended and the Board has assented that this honor should be conferred upon Harold Eugene Edgerton, D.Sc., Associate Professor of Electrical Engineering, Massachusetts Institute of Technology, 'in consideration of his invention of, and, with the aid of his assistants, his development of a high speed motion picture camera with a new type of illumination control, which has increased knowledge in the fields of pure and applied science' . . . Dr. Edgerton."

Dr. Staples: "In presenting to you this Potts Medal, may I also offer my congratulations, and express the confident

hope that many more good things will come from M. I. T. You men are doing a splendid job in the field of science."

PRESENTATION OF THE FRANKLIN MEDALS AND CERTIFICATES OF HONORARY MEMBERSHIP.

To Sir Chandrasekhara Venkata Raman, F.R.S., LL.D., D.Sc., Director, Indian Institute of Science, Bangalore, Mysore, India: Received by Sir Gerald Campbell, K.C.M.G., D.C.L. LL.D., Envoy Extraordinary and Minister Plenipotentiary, The British Embassy, Washington, D. C.

Dr. Staples: "The Chair recognizes Dr. T. D. Cope."

Dr. Cope: "Mr. President, the Board of Managers of The Franklin Institute, upon the recommendation of its Committee on Science and the Arts, is unanimously of the opinion that two Franklin Medals be awarded this year.

"One to Sir Chandrasekhara Venkata Raman, of Bangalore, Mysore, India, 'in recognition of his many brilliant contributions to physical science and of his leadership in the renaissance of scientific work and scientific education that has occurred in India during the last thirty years.'

"Our medalist was born in southernmost India fifty-three years ago. He was educated in India. While still an undergraduate, eighteen years of age, he contributed original papers on acoustics and optics to *Nature* and to the *Philosophical Magazine.*

"By competitive examination in 1907 young Raman secured appointment as a Gazetted Officer of the Indian Finance Department and served in this capacity for the next ten years, most of the time in Calcutta. During this decade he continued to work in physical science and contributed thirty original papers to *Nature,* to the *Philosophical Magazine* and to the *Physical Review.*

"In 1917 the Palit Professorship of Physics was established in the University of Calcutta, Raman was appointed to it and continued to occupy it until 1933. At the same time he served as Secretary of the Indian Association for the Cultivation of Science.

"Professor Raman first visited Europe in 1921 when he attended a Congress of the Universities of the British Empire

at Oxford. In 1924 he attended the meeting of the British Association held in Toronto, Canada, where he participated in a symposium on the Scattering of Light. In September 1924 Professor Raman represented India at the Centenary of The Franklin Institute in Philadelphia.

"Raman's studies of the scattering of light began in 1921. They have continued until the present day. In 1928 there came out of them the discovery of a new phenomenon in the spectra of scattered light which has been named in honor of its discoverer—the Raman Effect. Since its discovery two thousand scientific papers and a number of books have been written about this phenomenon, its significance and its usefulness.

"Honors have come to Professor Raman—honorary degrees, medals, fellowships in learned societies, the Nobel Prize and Knighthood.

"In November 1938 the Indian Academy of Science observed the fiftieth birthday of Sir C. V. Raman by publishing a Jubilee Volume of invited original papers written by the world's leading investigators of the Raman Effect. The first paragraph in this volume reads, in part:

" 'He is the outstanding figure in the renaissance of science which has been taking place in India during the last quarter of a century, and indeed with truth he may be designated as the creator and leader of that renaissance. The progressive enthusiasm for scientific studies and research which is witnessed on all sides in India today has largely been inspired by him and encouraged and sustained by his efforts. The personal example of his dedication to a scientific career, the brilliance and originality of his researches, the international character of the recognition which his work has received, his success as a teacher in training investigators who are now themselves guiding schools of research, his gift of eloquence which has served to stimulate a wide-spread interest in science, his achievements as a scientific administrator in creating facilities for research and establishing new schools of science, and his success in founding journals for publication of scientific work in India, are among the factors which have profoundly influenced the progress of science in the country.'

"Mr. President, it is a source of regret that, due to the war, Sir C. V. Raman is unable to be present in person. We are honored, however, by the presence of Sir Gerald Campbell, Envoy Extraordinary and Minister Plenipotentiary of the British Embassy, Washington, who has graciously consented to receive the Medal on behalf of Sir Chandrasekhara. It give me pleasure, Sir, to present Sir Gerald Campbell."

Dr. Staples: "Sir Gerald, it is most gracious of you to come to us today, in the interest of Dr. Raman. By power vested in me as President of The Franklin Institute, I have the honor and the pleasure of depositing with you the Franklin Medal and Certificate of Honorary Membership, and would ask that they be forwarded to Sir C. V. Raman through the diplomatic pouch, if that is permissible in these troublous times, which have prevented him from being present in person. And may I express to you, Sir, our deep appreciation of the helpful coöperation of the British Embassy in the efforts of The Franklin Institute to do honor to a brilliant British scientist."

Sir Gerald Campbell: "I am here today representing his Majesty's Ambassador, the Viscount Halifax, who sends you the following message:

"'I am sorry that I cannot be present today to receive the high award which The Franklin Institute has conferred upon Sir Chandrasekhara Venkata Raman, Director of the Indian Institute of Science at Bangalore.

"'Sir Venkata is among the most distinguished of his Majesty's subjects, and is preeminent among the many notable men of science whom India has given us. It is a source of legitimate pride in India's place in the modern world when Englishmen can see the scientific achievements of one of India's sons honoured by an American learned body of such high standing as The Franklin Institute in Philadelphia.

"'On behalf of Sir Chandrasekhara Venkata Raman I am happy to receive through Sir Gerald Campbell, his Majesty's Minister, this signal award, and will duly transmit it to its destination.'"

Having read the above message from Lord Halifax, Sir Gerald continued:

"May I add a few words of my own, with considerable presumption I admit, since I cannot speak from personal knowledge but only from what I have gathered from books, from travelers' tales, and from moving pictures, and I don't for a moment imagine that any of these—certainly not the tales and the movies—give one a real insight into the life and soul of India. But I cannot let this occasion slip without paying tribute to the contributions which Indians have made through the ages to the scientific knowledge of the world and to the cause of humanity. For, to quote Sir Jagdish Chander Bose: 'Not through material acquisition but in general diffusion of ideas and ideals can the true empire of humanity be established.' There are many names which could be mentioned. Your hero of today, Sir Venkata Raman, of whom I can be proud as a proxy, whereas if he were here himself he would have that humility which stamps the truly great; Sir Jagdish Bose, who is so well known to you here in the United States; Sir P. C. Ray; Dr. Saha and many others whose names occur to you, and towering above them all the great scientist of the 19th Century, Dr. Mahendralal Sircar 'perhaps the greatest promoter of scientific enquiry in India.' But what thrills one most is the knowledge that there are a number of brilliant young Indian workers in various fields of scientific activity whose work holds out promise of great things for the future. They 'will be a channel through which India will make in an increasing degree that contribution to Western and to world thought which those who know and love India are confident that she can make in so full a degree.' These words were spoken by the present Viceroy of India at the joint meeting of the Indian Science Congress and the British Association of Science in Calcutta early in 1939. And he also used these words: 'Perhaps the West will find in India's more general emphasis on simplicity and the ultimate spirituality of things a more positive example of the truths which the most advanced minds of the West are now discovering.'

"And that brings to my mind another and concluding quotation, this time from a Westerner, Romain Rolland: 'A great nation assailed by war has not only its frontiers to protect, it must also protect its good sense.'"

Dr. Staples expressed the appreciation of the Institute and the audience to Sir Gerald for his interesting messages. He then called upon Dr. T. D. Cope, Professor of Physics, University of Pennsylvania, to read an original paper prepared for this meeting by Sir C. V. Raman, entitled "The Scattering of Light in Crystals" which appears on page 203 of this issue.

To Edwin Howard Armstrong, Sc.D., Professor of Electrical Engineering, Columbia University.

Dr. Staples: "I now call upon Dr. A. F. Murray, sponsor for our other Franklin Medallist."

Dr. Murray: "Mr. President, the Board of Managers of The Franklin Institute, upon the recommendation of its Committee on Science and the Arts, unanimously voted to award a Franklin Medal to Dr. Edwin Howard Armstrong, Professor of Electrical Engineering, Columbia University, New York City, 'in recognition of his pioneer work in regeneration and the oscillating vacuum tube circuits, in the invention of the superheterodyne circuit, the super-regenerator, and a system of wide-swing frequency modulation, each an outstanding contribution to the communication art.'

"Dr. Armstrong's career as inventor began at the early age of twenty-two. While he was a student at Columbia University, in 1912, he invented the regenerative vacuum tube circuit.

"More inventions followed—inventions which today, in their worldwide use, overshadow, in breadth and practical importance, those of any other inventor in the radio field.

"We usually think that most great and helpful discoveries in chemistry, physics, radio and the like, come from the large, well-equipped laboratories of manufacturing companies. We note with interest, therefore, this exception. Dr. Armstrong has never been a part of the radio manufacturing industry. As a lone researcher, he has contributed such far-reaching improvements that, if these were suddenly withdrawn from us, not only would the vast radio industry itself come to an immediate halt, but radio communications throughout the world would cease and millions of listeners would be seated beside silent broadcast receivers.

"Armstrong graduated from Columbia University in 1913. During the first world war he was stationed at the United States Signal Corps Laboratories in Paris, France, as a Captain and later as a Major. Major Armstrong's contribution at this time was the superheterodyne. This not only was a great aid to Army radio but twenty years later we find that nearly all of the radio broadcast receivers in our homes employ the superheterodyne principle.

"In 1929 he received from Columbia University a Doctor of Science degree and since 1937 he has been Professor of Electrical Engineering at Columbia.

"Professor Armstrong, to whom more than thirty-three patents have been granted, is the author of numerous technical papers and the recipient of many awards. Among these are —the Medal of Honor of the Institute of Radio Engineers; from France, Chevalier de la Legion d'Honneur; the Egleston Medal from Columbia University; a National 'Modern Pioneers' award, and the Holley Medal of the American Society of Mechanical Engineers.

"For many years, in his research laboratory, Professor Armstrong has been working on the solution of the elimination of radio's 'Enemy Number One'—that is—Static. Three years ago he announced the solution—a system known as 'Wide-swing Frequency Modulation.' Did the radio world embrace this new idea with open arms? No. On the contrary, the inventor himself was forced to build and operate a high-power, FM broadcasting station, and in this way initiate experimentally a new system of broadcasting in the United States. At first it grew slowly, then rapidly, until now it has reached the accepted commercial stage. Thus today we are entering a new era of broadcasting, one which will bring us increased listener enjoyment in our homes through high-fidelity, noise-free radio reception.

"Mr. President, I have the honor and the pleasure of presenting to you for the award of a Franklin Medal, the outstanding radio inventor, Dr. Edwin Howard Armstrong."

Dr. Staples: "Dr. Armstrong, just as Sir Gerald as an Englishman took pride in the honor paid to a scientist of the British Commonwealth, so all of us take equal pride in your reception of a Franklin Medal. To those of you ladies and

gentlemen who have to do with the field of communications, the name of Major Armstrong is a household word; and all who have to do with communications take pride in Major Armstrong's accomplishments.

"To you, Sir, by virtue of my office as President of The Franklin Institute, I take the greatest satisfaction in presenting the report which accompanies the Medal award, the Franklin Medal, and a Certificate of Honorary Membership in The Franklin Institute."

Dr. Armstrong: "I know I should try to express how greatly I appreciate this honor which you have conferred upon me. To have had a part in the struggle which many men have waged with the effects of lightning for many years, and to receive an award bearing the name of the great philosopher who first brought it down from the clouds is indeed an honor which I shall never forget.

"But perhaps there is something that I can more fully express, regarding a new force of freedom in radio. . . ." (Dr. Armstrong's further statements are embodied in his paper "The New Radio Freedom" which appears on page 213 of this issue.)

Dr. Staples then thanked Dr. Armstrong for the presentation of his paper. He next called upon the sponsor for the Cresson Medal, Mr. F. H. Rogers.

PRESENTATION OF THE CRESSON MEDAL.

To The United States Navy.

Mr. Rogers: "Mr. President, seldom have the members of your Committee experienced such a feeling of deep satisfaction as they did in recommending the award of the Cresson Medal this year. The Board of Managers has voted that it shall be presented to the United States Navy 'in consideration of the development of means for saving human lives in disabled submarines, and the successful application of the United States Lung and Rescue Chamber to this end.'

"When a man joins the United States Navy, Mr. President, he *is* the Navy: Therefore, when your Committee inquired the names of the person or persons who had developed this humanitarian device, it was informed that 'it was a coöperative effort.'

"May I present to you, Sir, the Honorable Ralph A. Bard, Assistant Secretary of the Navy, who represents today, not only the group of skilful men who are directly responsible for this award, but also the pride of our country—THE UNITED STATES NAVY."

Dr. Staples: "By virtue of my office as President of The Franklin Institute I take great pleasure in presenting, through you, to your Department, the Cresson Medal of The Franklin Institute. May it find a place in the great museum of the Navy Department at Annapolis, which I visited recently.

"No man or woman could fail to go to that great museum and not get a tremendous inspiration to see the flags, the swords, the uniforms, the papers! For much of the fine memorabilia of the United States Navy, of its men and its accomplishments, are there. And, unless a better place for the Cresson Medal can be found in your Department, Mr. Secretary, we hope you will place it in that great museum."

Mr. Bard: "When the Committee on Science and the Arts began to investigate the development of a practical means for saving lives from disabled submarines, it asked for the name of the man who was responsible for perfecting the devices adopted by the United States Navy. We were forced to acknowledge that no name could be submitted to your Committee. The Navy Lung and Rescue Chamber are not the product of any one man's genius, nor of any two or three men.

"It is characteristic of our Navy that its excellence does not repose upon individual brilliance but upon the joint efforts of all its personnel working to a common end.

"When the Bureau of Construction and Repair of the Navy Department undertook to provide a practical device to rescue the entrapped crew of a disabled submarine, its members were aware of the magnitude of the task confronting them. Instead of consigning the task to an individual, they invited the coöperation of all officers and civilian personnel.

"As a result of their combined efforts the United States Navy now has, in the Lung, a satisfactory method of saving individuals and, in the Rescue Chamber, a highly successful device for group rescues. This achievement was the product,

as I have said, of many who contributed each in his own way and in the spirit of coöperation which distinguishes our Navy.

"I am very proud to receive the Elliott Cresson Medal on their behalf and to express their thanks for your recognition of their achievement.

"The award of this medal has so frequently been made to recognize the merit of valuable discoveries and inventions that I am sure its presentation has been accompanied with the expression of hope that the discovery or invention might have frequent application. Such will not be the case on this occasion. It must be our fervent hope that the need to use these inventions shall arise only upon rare occasions. But since it is the policy of the United States Navy to be prepared for all eventualities, it is a source of gratification to know that our brave and sturdy seamen can have the fullest confidence in the devices furnished for their greater security.

"Mr. President, we are very proud to have here today several representatives of the United States Navy who had very direct contacts with the apparatus we have been discussing. I should like to present them to you:

"Commander A. R. McCann, U.S.N., Submarine Base, New London, Connecticut, the officer most actively engaged in the development of the submarine rescue Chamber used in the saving of life in the sinking of the U.S.S. Squalus. The device was developed by the Bureau of Construction and Repair. Associated with Commander McCann were the late Lieutenant Commander J. W. Paige (CC), U.S.N. (Resigned), and the late Mr. F. R. Wheater of the Bureau. Others in the Bureau had a share in the development and the Bureau's regular design organization prepared the actual design of the chamber. Commander McCann is the officer who took a stimulating interest in the development. He also, under the direction of Admiral Cole, was the officer in direct charge of the Squalus rescue operations.

"Lieutenant Commander A. M. Morgan, U.S.N., the officer immediately in charge of construction of the rescue chamber in the New York Navy Yard. He also took part in the earlier tests of the chamber and, in company with Commander McCann and Mr. Paige, operated it on its first submergence which was in a flooded dry dock.

"Lieutenant R. N. Robertson, U.S.N., one of the survivors of the Squalus, who was brought out in the third ascent of the rescue chamber.

"Chief Metalsmith J. H. McDonald, U.S.N., Master Diver, and one of the operators of the submarine rescue chamber during the bringing out of survivors from the Squalus. He was in the chamber during the well-known fourth trip, in which the chamber jammed and was delayed for hours in its return to the surface. He was awarded the Congressional Medal of Honor.

"Mr. Frank M. Hobson, a civilian, represents the personnel in connection with the development of the submarine lung. It is the work of Commander C. B. Momsen, U.S.N., the late Lieutenant Clarence L. Tibbals, U.S.N. (Retired), and Mr. Hobson of the Bureau of Ships. The submarine lung was not used by any personnel escaping from the Squalus, but is a device of great importance in submarine safety.

"We also have with us in the audience, Mr. President, a crew from a submarine now in at the Philadelphia Navy Yard. I should like to present them to you as well."

Dr. Staples: "We are proud and happy to welcome you and these gentlemen who are members of your Department. It is a great honor for us to have you here.

"Now I am sure our audience would like also to meet—

"Rear Admiral A. E. Watson, Commander of the Fourth Naval District and Commandant of the Philadelphia Navy Yard;

"Honorable L. M. Robinson, the British Consul-General in Philadelphia; and

"Sardar Hardit Malik, India Government Trade Commissioner, New York."

After expressing the hope that all members of the audience would be present at the dinner in the evening, in honor of the Medalists, Dr. Staples declared the meeting adjourned.

MEDAL DAY DINNER.

At half after seven o'clock, daylight saving time, three hundred and thirty guests assembled in Franklin Hall, to pay further tribute to the Medalists of the afternoon. The dinner programme was as follows:

PROGRAM

DR. PHILIP C. STAPLES, *President*, Presiding

1. Introduction of Medalists.....THE PRESIDENT
2. "The Navy and Science"..HONORABLE RALPH A. BARD
   Assistant Secretary of the Navy
3. "Why We Do Not Make Inventions".....DR. EDWIN H. ARMSTRONG
4. "The Franklin Institute Keeping Up With the times".....DR. HENRY BUTLER ALLEN
   Secretary and Director
5. "The Truth, the Whole Truth, And Nothing But the Truth".DR. D. LEE CHESTNUT
   General Electric Company

NOTES FROM THE NATIONAL BUREAU OF STANDARDS.*

FIRE TESTS OF PARTITIONS.

The Bureau's studies of the permanence, economy, and safety of building constructions have included many fire tests. In Building Materials and Structures Report BMS71, which has just been released, tests to determine the effectiveness of wood and metal framed partitions as barriers to the spread of fire within buildings are described. Considering the number of types and tests included, a comparatively wide range of constructions is made available, from which selections can be made for a given purpose.

The tests covered solid and hollow partitions of both combustible and incombustible construction. The facings were, for the most part, boards or plaster. The limit of protection was assumed to have been reached when failure under the applied working load, collapse, or passage of flame occurred, or otherwise, when the temperature on the side not exposed to fire reached limits that might cause ignition of combustible materials in contact therewith. For ratings of one hour or more the partitions must also have withstood a hose stream application. The general method of conducting the tests and rating the performance is given in more detail in Standard Specifications for Fire Tests of Building Construction and Materials approved by the American Standards Association.

The partitions framed on 2 by 4 in. wood studs and faced with wood or wood fiber boards, and those of solid tongued and grooved wood construction 1½ to 1⅝ in. thick, were found to be among the most vulnerable to fire. The use of asbestos paper as membranes in these constructions delayed fire penetration and placed them in the 25 to 45 minute range, which is comparable to results with facings of flameproofed wood fiber board or gypsum wall boards. Partitions faced with ½ in. gypsum wall board and having

* Communicated by the Director.

mineral wool fill in the form of bats secured by nailing into the sides of the studs attained a 1-hr. rating. A 3-in. thick partition of prefabricated plywood panels filled with mineral wool attained a fire resistance of ¾ hr., and one of the same thickness of prefabricated steel panels filled with expanded vermiculite reached its limit in just under ½ hr., because of temperature rise on the unexposed side, but remained a barrier to fire for a longer period.

Wood-stud partitions faced with ½ in. thickness of sanded gypsum or lime plaster over wood lath qualified for the ½ hr. rating, which also was reached by the gypsum plaster applied over wood fiber board. Filling the stud space with mineral wool bats increased the fire resistance with wood lath and gypsum plaster to 1 hr. With lime plaster the mineral wool fill increased the fire resistance to an average of 40 min. With facings of ½ in. thick 1 : 2 sanded gypsum plaster on perforated gypsum lath, or of ¾ in. thickness on metal laths, a 1-hr. fire resistance rating was attained. Lime or portland cement plaster facings ¾ in. thick on metal lath gave ½ hr. fire resistance, and similar thickness of lime plaster gaged with Keene's cement, gave ¾ hr. Neat fibered gypsum plaster when applied 1 in. thick on expanded metal lath extended the fire resistance range for this type of partition up to 2 hr. These constructions, as well as all wood or wood-stud partitions, are rated as "combustible" according to the test specification.

The results with metal-framed hollow partitions differed little from those with wood-framed partitions having the same facings insofar as the rise of temperature on the unexposed surface was concerned, but the former retained their integrity better and remained longer as barriers to the spread of fire. These constructions were framed with formed sheet-steel channels and were of the non-bearing type.

The metal-framed solid plaster partitions were also of the non-bearing type and were framed on a single row of channels to which the metal lath or other plaster base was attached. With metal lath base and plaster having 1 part by weight of gypsum and 2 or 3 parts of sand, a 2½ in. thickness was required for a rating of 1 hr. from the standpoint of fire and hose stream resistance. For these, as for the hollow parti-

tions, the fire resistance for the same thickness was increased to over 2 hrs. by the use of unsanded gypsum plaster, to which wood fiber or short asbestos fiber was added to obtain workability. Similar partitions of 1 : 2 and 1 : 3 sanded portland cement plaster, 2 to 2½ in. thick, applied in the usual manner with the trowel, qualified for a rating of ½ hr., the fire resistance being limited by cracking and spalling of the plaster. These effects were even more pronounced with a more dense mortar applied as a spray by means of compressed air. However, by substituting sawdust for one half of the volume of the sand these effects were almost entirely eliminated and the 1-hr. fire resistance was obtained with a 2½ in. thickness.

The above fire resistance periods are to be understood as applying to the construction as a whole. Any wood framing will be ignited and may be burning freely before failure under load, passage of flame, or other limiting condition is reached. However, from temperature indications at points between the fire-exposed facing and the studs, information was obtained on the effectiveness of the facings as protection to the wood framing. The general limits of this protection were found to be from one sixth to one third of the fire resistance of the partition as such. The lowest was 5 min. for facing of ½ in. wood fiber board and the highest 35 min. for 1 in. of neat fibered gypsum plaster on metal lath. For the same kind and thickness of plaster, the board plaster bases gave more protection than application on metal lath.

On the basis of the data obtained in this series of tests, fire resistance ratings for 64 different partition constructions have been derived. For several of them values for two or three thicknesses are given. For incombustible materials not subject to decided cracking or spalling as exposed to the furnace test, it was found that the fire resistance, as limited by the temperature rise on the side not exposed to fire, varied approximately with the 1.7 power of the thickness of solid partitions or combined thickness of facings for those of hollow type. This is in fair agreement with relations derived from the theory of heat conduction.

Copies of BMS71 are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 20 cents each.

THERMAL EXPANSION OF BUILDING BRICK.

In order to obtain data useful to designers of brick masonry structures, the thermal expansion of 139 bricks representing one sample of sand-lime, 9 of fire-clay, and 61 of clay and shale bricks was measured by Culbertson W. Ross, using Tuckerman optical strain gages over the temperature range − 10 to + 40° C. (14 to 104° F.). The gages were calibrated against bars of known thermal expansion.

The coefficients of thermal expansion were: Clay bricks, 4.2 and 12.4 millionths per ° C. (2.3 to 6.9 per ° F.), with an average of 6.0 (3.3); shale bricks, 4.7 and 6.8 (2.6 to 3.8), with an average of 6.1 (3.4); fire-clay bricks, 3.0 and 4.6 (1.7 to 2.6), with an average of 3.9 (2.2). The coefficient of the one sample of sand-lime brick was 10.5 (5.8). The coefficients of 87 percent of the clay and shale bricks were within the range 5 to 7 (2.8 to 3.9).

In RP1414 in the *Journal of Research* for August, the compressive strength, modulus of rupture, 5-hour boiling absorption, 24-hour water absorption, and the saturation coefficient are given for each brick. No relation was observed between the thermal expansion and these properties.

MODULUS OF RUPTURE OF BEAMS.

It has long been evident, from the results of tests to determine the strength of materials, that even duplicate specimens will almost invariably differ in strength, sometimes quite markedly. This inherent variation is readily understandable in a heterogeneous material such as concrete, composed of cement and various sizes of aggregate. The inter-arrangement of the aggregate particles would naturally be expected to cause strength variations.

The strength of the elementary volumes composing a structural unit will vary, and at a given stress the weakest portion will determine the location of the failure. In a paper before the Chicago meeting of the American Society for Testing Materials on June 26, John Tucker, Jr., showed that, by using the mathematical theory of probability, it is possible, if the distribution of strengths of small elements of volume of the material be known, to compute the mean

strengths of larger units composed of specified numbers of these small elements; it is also possible to compute the mean strength, and the scatter in strengths, of structural units of a given size from the mean strength and strength scatter of similar units of different known dimensions.

To illustrate the method, consider a very long chain of links, which are uniform within the limits of modern machine production. Every link would appear to be alike.

If, however, single links are cut from the chain, in some ordered manner, such as every hundredth link, and these individual links are tested in tension, the strengths would not all be alike but would be scattered, the degree of scatter varying with the control of material and manufacturing process. The mean strength of these selected links could be computed, and the scatter could be expressed in terms of the standard deviation or some other parameter commonly used in statistical analysis.

If now the remaining chains of 97 links (two links having been lost by cutting to obtain the single links), are tested, a set of strengths will be obtained which will also be scattered. The average strength of the chains, however, will be less than the average strength of the single links originally tested, because in each chain the weakest of the 97 links will fail. On the average, the same strengths as for the chains would be obtained if the single links were grouped in order into lots of 97, and the weakest link in each lot of 97 were selected.

By the mathematical theory of probability the mean strength and scatter in strengths of chains of any specified length can be computed from the mean strength and the scatter in strengths of single links.

The theory, as developed by Mr. Tucker, has been applied to the strength of beams, and has provided an explanation why, for example, beams centrally loaded have a greater modulus of rupture on the average than beams loaded at the third point; and why increasing the length or the depth of beams decreases their mean modulus of rupture and decreases the scatter of the moduli of rupture.

AIR CONTENT OF FRESH CONCRETE.

It has been indicated that the air content of freshly placed concrete is a factor which may greatly affect its properties, particularly its weather resistance.

The amount of air in concrete may be estimated from a knowledge of the apparent specific gravities of the materials, the proportions and the weight of a known volume of the concrete. A new and improved method for the air-content determination has been developed by G. L. Pigman. In this method the measured volume of concrete is inundated with water, vacuum is applied, and the container is agitated by rolling in order to release the air bubbles. The volume of air released is measured by replacement with water.

Reproducible results were obtained by this method on fairly wet concretes, but the results upon drier concretes were less consistent. This may be attributed to the fact that drier mixes cannot be uniformly compacted into the forms.

The use of a finer sand resulted in the incorporation of much more air; more cement in the mix slightly reduced the air content. A number of grinding aids, when added to the concrete, increased the air content from the normal of one percent to as high as 14 per cent. approximately. Fly ash did not appreciably change the air content.

QUANTITATIVE DETERMINATION OF FLUORINE IN ORGANIC COMPOUNDS.

As the industrial application of organic fluorine derivatives has increased, especially for refrigeration, plastics, solvents, insecticides, etc., the quantitative determination of fluorine in these compounds becomes more important. Numerous methods have been devised, obviously for obtaining the one that is most convenient. In the *Journal of Research* for August (RP1406), Dirk H. Brauns describes a new method which is based on the loss in weight of a glass container by the etching action of hydrofluoric acid generated by the decomposition of the organic fluorine compound by sulfuric acid and potassium nitrate. The method, which could be adapted for volatile derivatives, is very simple and can be

performed in a short time; it requires no expensive apparatus or elaborate set-up.

MICROSCOPIC STRUCTURE OF THE WOOL FIBER.

A growing wool fiber consists of a root and shaft, the former being the living region situated beneath the surface of the skin, whereas the latter is the nonliving portion that extends above the skin surface. Increase in length of the fiber is brought about by the proliferation of new cells in the root and the subsequent emergence of these cells into the shaft. The latter is composed of dead cellular units which usually are arranged in three layers, an outer layer of scales, a middle region called the cortex, and a central core or medulla. The relative thickness of each of these layers varies considerably in different fibers. Kemp, for example, has a large medulla, whereas in the best grades of wool the medulla is either absent or very small. An investigation was undertaken by Charles W. Hock, Robert C. Ramsay, and Milton Harris, research associates of the Textile Foundation at the Bureau, to obtain information concerning the fine details of structure of wool fibers and especially of their constituent scale and cortical cells.

The cortex was found to consist of spindle-shaped cells. Near the center of each cell is a nucleus which has a granular structure, and which differs in its staining reactions from the rest of the cell. Upon handling single cortical cells with the fine glass needles of a micromanipulator, they can be dissected into many fibrils, indicating that their striated appearance is due to the presence of fibrils and not merely to surface irregularities. In polarized light, the fibrillar part of the cortical cells appears birefringent whereas the nucleus does not.

The scales show little internal organization such as that exhibited by the cortical cells. Unlike the cells of the cortex they are not appreciably affected by pepsin. They usually remain attached to each other in the form of tubes corresponding to their arrangement in intact fibers, and are found to overlap in a manner comparable to the arrangement of shingles on a roof. Both before and after staining, the scales show practically no birefringence.

Since the cells of the root are alive and growing, whereas the cells of the shaft are dead, it is not surprising to find physical and chemical differences between these two regions of the hair. In addition to microscopically detectable differences in structure between the cells in the root and those in the shaft, microchemical color tests also show dissimilarities. The nuclei in the cells of the root react positively to a test which shows that they contain nucleic acid, whereas the nuclei in the cells of the shaft give a negative test. When fibers are examined in polarized light the shaft appears birefringent whereas the root does not. These, and other observations clearly indicate that as the living cells of the root emerge into the shaft a number of physical and chemical changes take place simultaneously.

When wool is treated with chlorine water, vesicles or sacs are formed on the surface of the fibers (Allworden reaction). That the formation of these sacs is in some way associated with the scales has been suggested by many investigators. Conflicting views prevailed, however, as to whether the sacs arose solely from the scales or whether the latter were merely pushed out by a swelling of a layer of material which lay beneath them. In the present investigation as reported in full in the *Journal of Research* for August (RP1412), evidence was obtained in support of the view that the sacs arise in the scales alone. It was found that when fibers are placed in chlorine water the upper and lower surfaces of each scale cell separate to form a swelling.

REVISED SIMPLIFIED PRACTICE RECOMMENDATION FOR HOSPITAL PLUMBING FIXTURES.

Simplified Practice Recommendation R106–41, Hospital Plumbing Fixtures, became effective on July 1, 1941. This is a revision of the original edition promulgated in 1930. The recommendation covers a simplified schedule of types and sizes of plumbing fixtures for hospital use, and includes references to grading rules, nomenclature, and definitions for porcelain ware, vitreous china plumbing fixtures, sanitary cast iron enameled ware, and earthenware.

The publication includes, in addition to the simplified schedule, a brief history of the project, and lists the members of the standing committee and the acceptors. Until the

printed issue is available, free mimeographed copies of this revision may be obtained from the Division of Simplified Practice, National Bureau of Standards, Washington, D. C.

TABLE OF NATURAL LOGARITHMS.

The Bureau is acting as sponsor and distributing agency for a series of mathematical tables which are being prepared by the Work Projects Administration under the direction of Dr. Arnold N. Lowan. The seventh of these tables to be issued is the first of a series of four volumes giving values of the natural logarithms to 16 places of decimals. This particular volume covers the integers from 1 to 50,000.

In the range and value of the argument, that is, in the number of significant figures of the argument and also the number of decimal places of the logarithm, these tables supersede all others. They should prove particularly convenient to engineers and other practical computers who have frequent use for natural logarithms and wish to obtain them with the least possible effort and in the shortest time.

Remittance must accompany order and should be sent to National Bureau of Standards, Washington, D. C. The price for this volume, which contains 523 pages bound in buckram, is $2.00.

NEW AND REVISED PUBLICATIONS ISSUED DURING JULY 1941.

JOURNAL OF RESEARCH.[1]

Journal of Research of the National Bureau of Standards, volume 26, number 6, June 1941 (RP1390 to RP1397, inclusive). Price 30 cents. Annual subscription, 12 issues, $3.50.

RESEARCH PAPERS.[1]

(Reprints from June 1941 *Journal of Research*.)

RP1391. Analysis of dental amalgams containing mercury, silver, gold, tin, copper, and zinc. Harold J. Caul and Irl C. Schoonover. Price 5 cents.

[1] Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D. C. Subscription to Technical News Bulletin, 50 cents per year; *Journal of Research*, $3.50 per year (to addresses in the United States and its possessions and to countries extending the franking privilege); other countries, 70 cents and $4.50, respectively.

RP1392. X-ray studies of compounds in the system PbO-B_2O_3 and K_2O-PbO-SiO_2. Howard F. McMurdie. Price 5 cents.

RP1393. Slopes of *pv* isotherms of He, Ne, A, H_2, N_2, and O_2 at 0° C. Carl S. Cragoe. Price 10 cents.

RP1394. Comparative tests of chemical glassware. Edward Wichers, Alfred N. Finn, and W. Stanley Clabaugh. Price 10 cents.

RP1395. Spectrophotometric determination of praseodymium, neodymium, and samarium. Clement J. Rodden. Price 5 cents.

RP1396. Critical study of the determination of carbon monoxide by combustion over platinum in the presence of excess oxygen. Joseph R. Branham, Martin Shepherd, and Shuford Schuhmann. Price 10 cents.

RP1397. Determination of freezing points and amounts of impurity in hydrocarbons from freezing and melting curves. Beveridge J. Mair, August R. Glasgow, Jr., and Frederick D. Rossini. Price 10 cents.

BUILDING MATERIALS AND STRUCTURES.

Reports.[1]

(Persons who wish to be notified of new publications in the Building Materials and Structures series as soon as they are available should write to the Superintendent of Documents, Government Printing Office, Washington, D. C., asking that their names be placed on the special mailing list maintained by him for this purpose.)

BMS71. Fire tests of wood- and metal-framed partitions. S. H. Ingberg and Nolan D. Mitchell. Price 20 cents.

Simplified Practice Recommendations.[1]

R68–41. Metal and nonconducting flashlight cases. (Supersedes R68–33.) Price 5 cents.

R70–41. Salt packages. (Supersedes R70.) Price 5 cents.

Commercial Standards.[1]

CS60E-41. Hardwood dimension lumber (exports). Price 5 cents.

Technical News Bulletin.[1]

Technical News Bulletin 291, July 1941. Price 5 cents. Annual subscription, 50 cents.

MIMEOGRAPHED MATERIAL.

Letter Circulars.

(Letter Circulars are prepared to answer specific inquiries addressed to the National Bureau of Standards and are sent only on request to persons having definite need for the information. The Bureau cannot undertake to supply lists or complete sets of Letter Circulars or send copies automatically as issued.)

LC645. Methods of using standard frequencies broadcast by radio. (Supersedes LC567.)

LC648. Home heating problems: List of publications and articles. (Supersedes LC284.)

LC652. Fluorescent lamps.

LC654. List of Simplified Practice Recommendations. (Supersedes LC629.)

RECENT BUREAU ARTICLES APPEARING IN OUTSIDE PUBLICATIONS.[1]

Magnetism and its uses. Paul R. Heyl. *Proc. Am. Philosophical Soc.* (Independence Square, Philadelphia, Pa.), **84**, 339 (May, 1941).

Note on the measurement of the permeability of leather to water vapor. Robert B. Hobbs. J. Am. Leather Chemists Assn. (Ridgway, Pa.), **36**, 346 (June, 1941).

Report of the Secretary, Horological Institute of America, Twenty-first Annual Meeting. R. E. Gould. *J. Horological Inst. Am.* (c/o National Bureau of Standards, Washington, D. C.), No. 9, 10 (June, 1941).

Pitting and its effect on the fatigue limit of steels corroded under various conditions. D. J. McAdam and G. W. Geil. Preprint 33 Am. Soc. Testing Materials (260 South Broad St., Philadelphia, Pa.), (June, 1941).

[1] These publications are not obtainable from the Government. Requests should be sent direct to the publishers.

Influence of austenitic grain size on the critical cooling rate of high-purity iron-carbon alloys. T. G. Digges. *Trans. Am. Soc. Metals* (7301 Euclid Ave., Cleveland, Ohio), **29**, 285 (June, 1941).

Comparative tests of chemical glassware. Edward Wichers, Alfred N. Finn, and W. Stanley Clabaugh. *Ind. Eng. Chem. Analytical Ed.* (1155 16th St., N. W., Washington, D. C.), **13**, 419 (June, 1941).

The resistivity of interstellar space. Fred L. Mohler. *Physical Rev.* (Am. Inst. of Physics, 175 Fifth Ave., New York, N. Y.), **59**, 1043 (June 15, 1941).

RADIO OBSERVATIONS OF THE IONOSPHERE DURING AN ECLIPSE.

With the beginning in about 1925 of long-distance radio communication at high frequencies, interest in the ionosphere also commenced. Since that time a great deal of work, both experimental and theoretical, has been carried on at a number of places in this and other countries, in the study of the properties of the ionosphere. The ionosphere is made up of two and sometimes three more or less well defined ionized layers which are capable of returning radio waves to the earth. The lowest of these, the E layer, is found at about 68 miles above the surface of the earth, the F_1 between 87 and 155 miles, and the F_2 between 90 and 250 miles. All radio transmission over long distances takes place by virtue of refraction of the waves back to earth from one or another of these ionized layers. For example, transmission over a distance of 4,000 miles may require two hops with the wave striking the ionosphere at two places. The need for more than one jump for long distances is caused by the earth's curvature.

Since the sun is the main, if not the sole source of the ionizing force responsible for the formation of the ionized regions, it is of interest to study the ionosphere in terms of time of day, season, sunspot cycle, and any other occurrence which affects the amount of energy reaching the ionosphere. As an example of the amplitude of the changes, the ion density of the F_2 region may vary over a range of 10 to 1 between day and night and over a range of 4 to 1 from sunspot maximum to sunspot minimum.

The regular experiments which are being carried on continuously give a measure of the heights and densities of ionization of the layers so that it is possible to interpret and predict the characteristics of long-distance radio transmission.

One of the important factors in the study of the ionosphere is the rate of recombination of the ions. Although an estimate may be made of the recombination coefficient from diurnal curves, a solar eclipse gives a unique opportunity for its determination, since the ionizing force is cut off rapidly. Besides being important in the study of the ionosphere, a knowledge of the recombination coefficients of the various layers gives a check on the estimates of temperatures and pressure in the high atmosphere.

Measurements of heights and ion densities were made during the eclipse described in the preceding item, and from the values measured, recombination coefficients have been estimated for the various layers. The results of these measurements will be published as one of the papers in the eclipse monograph of the National Geographic Society.

During the eclipse, which had a period of totality of 282 seconds at the ground, the ion density of the E and F_1 layers decreased to about 22 per cent. of normal. The minimum density corresponds to a recombination coefficient of about 2×10^{-8} for the E layer and about 10^{-8} for the F_1 layer. The rate of decrease, however, and the fact that the time of minimum density occurred at the middle of totality indicate much greater coefficients. An apparent anomalous effect was observed, in that the ion density began to increase before third contact.

In the case of the F_2 layer, information was not complete, but the minimum of ion density approached approximately half of normal, and apparently reached a minimum about an hour after totality. Up to the end of totality the decrease in ion density corresponded to a recombination coefficient of about 10^{-10}, but the density observed some time after totality was much less than would have been expected for this coefficient.

A definite decrease in ion density was observed at the same time that the moon obscured a large sunspot. This may

be significant in identifying the source of certain ionizing radiation with given areas of the sun.

DENSITY OF CRYSTALLINE RUBBER.

The density of crystallized rubber may be computed from the results of X-ray investigations or it may be determined directly by well-known methods. If the computed density agrees with that found by direct measurement, it serves to confirm the structure on which the calculated value was based, and direct observations of the density could be used to determine the degree of crystallization. Unvulcanized rubber may be crystallized by stretching it at room temperatures or by subjecting it to appropriate low temperatures. When it is stretched quickly, an orientation of structure occurs parallel to the direction of elongation, the rubber crystallizes, and a change of volume takes place. Rubber crystallized by stretching appears as spots in the X-ray pattern, that crystallized by chilling appears as rings, but their measurements agree closely. In the past, the calculated densities have been greater than unity. More recent calculations have given lower values, the lowest being 0.965.

In recent work at the Bureau, W. Harold Smith and Nancy P. Hanna have determined, by direct experiment, densities of amorphous rubber, of unstretched crystallized rubber and of rubber crystallized as completely as possible by stretching it. The report of the work will be published in the September JOURNAL OF RESEARCH as RP1416. With the amorphous material, the determinations were made in distilled water at 25° C. With the crystallized material, they were made by weighing the rubber immersed in a mixture containing equal parts by weight of acetone and water, or in amounts adjusted to make the mixture of the same density as the specimen, and then the density of the liquid was determined. The measurement was made at −10° C., which is below the lowest observed melting point of crystalline rubber produced from ethereal solution. At 25° C., the density of amorphous smoked sheet was found to be 0.906. With purified, amorphous petroleum ether-sol rubber, the values ranged from 0.899 to 0.902 with different preparations of material. These densities are lower

than any reported in the literature. The range is much less than the differences reported for the densities obtained with impure, and for others obtained with pure, total rubber.

At −10° C., the density of crystalline, unstretched smoke sheet varied from 0.950 to 0.952; that of crystalline petroleum ether-sol rubber ranged from 0.948 to 0.951. The density of amorphous smoked sheet at −10° C. was 0.932 which was calculated from the value of 0.906 observed at 25° C. That of amorphous petroleum ether-sol at −10°C. was 0.928, based on 0.902 observed at 25° C. Smoked sheet stretched almost to the breaking point, and crystallized further at −15° C., had a density of 0.960 at −10° C. Stretching caused an increase, not more than 0.01 greater than that of unstretched crystallized rubber. The increase in stretched rubber is generally believed to be caused by a form of packing in crystallization of a fibrous type. Higher densities were found only by racking the rubber, that is by warming and stretching rubber repeatedly; by this technic very high elongations are possible. It is reported in the literature that the density becomes constant at 2,000 per cent. elongation. Its value observed at some room temperature was 0.953. The density at 2,000 per cent. elongation appears to be that of completely crystallized rubber, and when corrected for the temperature used in any X-ray investigation, is a reasonable guide for deductions about structure.

CARBON DIOXIDE AND WATER EVOLVED FROM LEATHER.

The oxidation of vegetable-tanned leathers has been associated with the darkening of the colors of solutions and of materials containing tannin, with the difficulty in determining the moisture content of leathers, and with the deterioration of vegetable-tanned leathers in storage. In previous studies, it was shown that when vegetable-tanned leathers were heated in the presence of air or oxygen at 100° C., carbon dioxide was evolved. The amounts of carbon dioxide evolved at a constant temperature varied linearly with the percentages of the total nitrogenous materials extractable by a 0.1 *N* solution of sodium carbonate after these leathers had been subjected to oxygen under pressure.

RP1418, in the September JOURNAL OF RESEARCH, describes a more nearly complete study, by Joseph R. Kanagy, of the oxidation of vegetable-tanned leathers. The rates of evolution of carbon dioxide and water from untanned hide powder and from chestnut-, quebracho-, cutch- and sumac-tanned leathers in the presence of oxygen or air, or of an inert gas, nitrogen or helium, in the range of temperature from 60° C. to 140° C., were determined. Hide powder evolves much less carbon dioxide and water than the leathers.

The rate of evolution of carbon dioxide from the leathers in air and in oxygen in the majority of cases increases by a factor of approximately 3 for every 20° C. rise in temperature. Since considerable amounts of carbon dioxide and water are produced in the presence of oxygen or air, but very little in the presence of an inert gas, the reaction appears to be an oxidation. The amounts of carbon dioxide emitted give a straight-line correlation with the percentages of the total nitrogenous materials extractable by a 0.1 *N* solution of sodium carbonate from leathers treated under the same conditions.

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LIBRARY NOTES.

Photostat Service. Photostat prints of any material in the collections can be supplied on request. Orders received in the morning are filled the same day. The average cost for a print 9 × 14 inches is thirty-five cents.

AERONAUTICS.

U. S. Civil Aeronautics Administration. Bulletin 28. 1940.

BIOLOGY AND BIOCHEMISTRY.

ROSE, MARY SWARTZ. Feeding the Family. Fourth Edition. 1940.

CHEMISTRY AND CHEMICAL TECHNOLOGY.

GLASSTONE, SAMUEL, KEITH J. LAIDLER, AND HENRY EYRING. The Theory of Rate Processes. First Edition. 1941.

JACOBS, MORRIS B. The Analytical Chemistry of Industrial Poisons, Hazards and Solvents. 1941.

KOLTHOFF, I. M., AND J. J. LINGANE. Polarography. 1941.

MEE, A. J. Higher Chemical Calculations. 1941.

MELLAN, IBERT. Organic Reagents in Inorganic Analysis. 1941.

Society of Chemical Industry. Reports of the Progress of Applied Chemistry. Volume 25. 1940.

SUTERMEISTER, EDWIN. Chemistry of Pulp and Paper Making. Third Edition. 1941.

ENGINEERING.

Battelle Memorial Institute. Prevention of Failure of Metals under Repeated Stress. 1941.

MILITARY ENGINEERING.

BARUCH, BERNARD M. American Industry in the War. 1941.

NAVAL ARCHITECTURE AND NAVIGATION.

Brassey's Naval Annual. 1941.

Janes Fighting Ships. 1940.

PHYSICS.

RAMSEY, A. S. An Introduction to the Theory of Newtonian Attraction. 1940.

NOTES FROM THE BARTOL RESEARCH FOUNDATION.

FURTHER EVIDENCE FOR A SINGLE COMPONENT IN THE PRIMARY COSMIC RADIATION.*

BY

W. F. G. SWANN.

In former communications,[1–4] the writer has given reasons to suppose that there is *no electron component to the primary cosmic radiation*, that the mesotrons are secondary to primaries, and that the only electrons in the atmosphere are secondary to the mesotrons.[5] He has pointed out, moreover, that insofar as mean life considerations are more potent than energy loss in determining variation of mesotron intensity with altitude, such variation in intensity should follow approximately an exponential law with a *single coefficient* when plotted against *true distance*. When intensity is plotted against *water equivalent* distance, the curve becomes compressed parallel to the distance axis in such a manner that the result is an apparent increase of absorption coefficient with altitude.[3]

The purpose of the present communication is to add further evidence in support of the foregoing views. Our interest concerns that region of the atmosphere which lies below the altitudes at which the approach to a maximum is felt.[6]

The following table gives measurements made by W. F. G. Swann and W. E. Danforth.[7] In curve A, $\log_{10} I/I_0$, the

* Reprinted from *The Physical Review*, **59**, 836 (1941).

[1] W. F. G. Swann, *Phys. Rev.*, **56**, 209 (1939).

[2] W. F. G. Swann, *Rev. Mod. Phys.*, **11**, 242 (1939), (see in particular pp. 251–254).

[3] W. F. G. Swann, *Phys. Rev.*, **58**, 200 (1940).

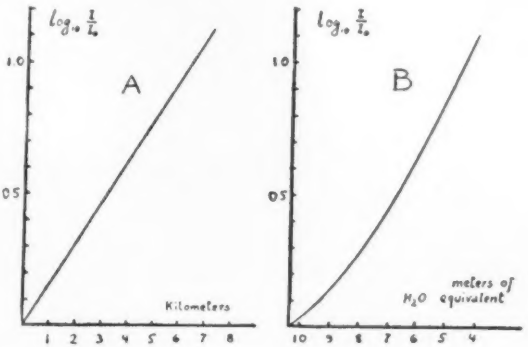
[4] W. F. G. Swann, *Phys. Rev.*, **59**, 770 (1941).

[5] Further evidence to support these views has also been supplied by M. Schein, W. P. Jesse and E. O. Wollan, *Phys. Rev.*, **59**, 615 (1941).

[6] The maximum becomes accounted for on the old and new views, but in slightly different fashion.

[7] W. F. G. Swann and W. E. Danforth, J. FRANK. INST., **228**, 43 (1939).

logarithm of the ratio of intensity to that at sea level is plotted against *true altitude in kilometers*. In curve B, $\log_{10} I/I_0$ is plotted against water equivalent altitude. The constancy of the slope of A bears out the conclusions cited above, and the change of slope of B shows how, on a water equivalent basis, the existence of an increase of absorption coefficient with altitude, and a consequent existence of more than one component, is simulated.



A—intensity variation *vs.* true altitude; B—intensity variation *vs.* water equivalent altitude.

If x represents true altitude in kilometers, and $I = I_0 \exp[-\mu x]$ we obtain, from the slope of A, $\mu = 0.156 \times 2.3 = 0.36$. Now if v is the velocity of the mesotrons, and t the time to travel the distance x, we may write $\mu x = \mu v t = 0.36 \times 3 \times 10^5 t = 10^5 t$ where we have assumed v equal to the velocity of light for purely kinematical purposes. Thus $I = I_0 \exp[-10^5 t]$.

If the rays disappeared simply by mean life considerations, we should have $I = I_0 \exp[-t/\tau]$ where τ is the mean life. A comparison of these two expressions gives $\tau = 10^{-5}$ sec. If the mean life for a stationary mesotron is 10^{-6} sec., this tells us that the mesotrons would have to have a mass 10 times the rest mass, which would give them an energy of 10^9 ev. If we should assume Yukawa's value 5×10^{-7} sec. for the mean life for a mesotron at rest, the corresponding energy would be 2×10^9 ev. This value is sufficiently near the probable average value of the energy of the mesotrons to

provide support to the foregoing views. A distribution of energy introduces a distribution of apparent absorption coefficients, but high energies give small absorption coefficients, and the story provided by energy distribution for high energies concerns increase of hardness for great depths, where, of course, disappearance of rays by energy absorption becomes more important.

THE REST MASS OF THE MESOTRON.*

BY

PAUL WEISZ.

The experimentally found values for the lifetime at rest of the cosmic-ray mesotron, from recent reliable investigations by various authors, are directly compared after recalculating them on the basis of the same assumed rest mass. The thus corrected values for the lifetime still disagree, but are shown to be a function of the average path length of the radiation employed in each experiment. When, instead of the existence of only one possible value for the rest mass for which we have no experimental evidence, a distribution in rest masses is assumed, the values obtained in these measurements represent a "pseudo life-time" which should be a function of the path of the radiation in just the manner found, this being a consequence of the average rest mass decreasing along the path.

The same assumption leads to explanations of other experimental findings, and predicts an actual lifetime τ_0 much smaller than any measured value, strongly indicating that upon correcting the measured results on the basis of the existence of a mass distribution, a value of the order of Yukawa's original prediction $\tau_0 = 5 \times 10^{-7}$ sec. may very well be obtained.

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* An abstract of a paper published in full in *The Physical Review*, **59**, 845 (1941).

NOTES FROM THE BIOCHEMICAL RESEARCH FOUNDATION.

Seminar on the Function of Sulfur Linkages in Insulin.*—DR. GAIL L. MILLER of the Department of Animal and Plant Pathology, the Rockefeller Institute for Medical Research, Princeton, New Jersey, lectured on May 23, 1941, before the Seminar Group of the Biochemical Research Foundation on the function of sulfur linkages, including a description of his ultracentrifuge studies on insulin.

One of the properties of insulin which aided Professor J. J. Abel in the purification of the hormone was its sodium carbonate-labile sulfur. Abel found that the labile sulfur and the activity of different preparations of insulin went hand in hand. Crystallized insulin contains close to 3.3 per cent. sulfur. The identification of this sulfur in terms of amino acids has been a problem in Professor du Vigneaud's laboratory for a number of years. According to the early data, about three-fourths of the sulfur was accountable as cystine. During attempts to find another sulfur-containing amino acid in insulin, it was demonstrated that there was no thiolhistidine or methionine present in the protein. It was finally shown that the sulfur was entirely represented as cystine and that the low values previously obtained were due to incomplete hydrolysis of the protein and to a partial destruction of cystine during hydrolysis. The hydrolytic agent for the insulin employed was 20 per cent. hydrogen chloride in 50 per cent. formic acid. The formic acid appeared to protect the cystine during hydrolysis.

The importance of the intact, oxidized state of sulfur linkages to physiological activity was first clearly demonstrated by du Vigneaud and coworkers. The sulfur linkages in the insulin were reduced by the specific method of Anson and Mirsky in which an excess of soluble sulfhydryl compound is used. Reduction of the insulin was followed by inactivation. Furthermore, reoxidation did not lead to reactivation.

* Abstract prepared by the author.

It was supposed that reduction caused fragmentation and that the fragments were not properly reunited during reoxidation. Wintersteiner extended this work and found that the rate of inactivation was much greater than the rate of reduction. Recently Freudenberg and Wegmann have reported that reduced insulin may be partially reactivated if it is treated with oxygen or hydrogen peroxide in the presence of an excess of cystine or glutathione. This was explained on the hypothesis that the insulin molecule consists of a long chain along which small branches are bridged by way of disulfide linkages; reactivation in the presence of cysteine or glutathione was possible because of the substitution of these units for the original branch chains. Stern and White, who also have made a study of reduced insulin, found that under specified conditions, a preparation might be obtained which possessed 50 per cent. of the potency of the starting material. The extent of reduction corresponded to one or two out of the possible eighteen disulfide linkages of insulin. It was postulated that the particular linkages which were reduced might have a special function.

In the present study it was desired to obtain more definite evidence as to whether the insulin molecule is broken into smaller fragments on reduction. Among the possibilities to be considered are, first, that reduction would yield fragments of approximately equal size, secondly, that according to Freudenberg's hypothesis, long chain units together with small branch fragments would be formed, and, thirdly, that reduction would cause no breakdown whatsoever, though possibly a change in shape of the insulin molecule would result.

In order to determine by physical means the distribution of particle sizes in solutions of reduced insulin, a detailed study has been made with the aid of the ultracentrifuge. The investigation was carried out in Upsala in coöperation with Kjell Andersson by courtesy of Professor Svedberg. Samples of insulin were reduced to varying extents and then subjected to study in the analytical centrifuge. Similar experiments were carried out on other proteins and the results were compared. An ultracentrifuge study was also made on native and reduced insulin preparations dispersed in the commercial detergent Duponol.

Preliminary to the above studies, measurements of sedimentation and diffusion constants were carried out on the native insulin for the purpose of re-determining the molecular weight of the protein. Previous molecular weight measurements made by the sedimentation equilibrium method may, according to Svedberg and Pedersen, have given too low a value. The diffusion measurements which had been made by Polson were carried out on commercial insulin which may have been impure so that it was desirable to repeat the determinations with more highly purified material. The results of the present studies, described in detail in the seminar, will be published elsewhere in the near future.

The Correlation of Bacterial Growth with Oxygen Consumption.—MARGARET E. GREIG and J. C. HOOGERHEIDE (*Journal of Bacteriology*, **41**, 549, 1941). The oxygen uptake per cell in growing cultures of different species of bacteria increases to a maximum value early in the logarithmic phase of growth and then slowly decreases. Oxygen uptake of growing cultures of bacteria was found to be directly proportional to bacterial content determined nephelometrically, for *Proteus vulgaris*, *Staphylococcus aureus*, *Pseudomonas fluorescens*, and one strain of yeast—*Willia anomala*. Since oxygen uptake is directly proportional to bacterial content, under favorable conditions, measurement of the rate of oxygen uptake constitutes a convenient method for the measurement of the rate of growth.

Evaluation of Germicides by a Manometric Method.—MARGARET E. GREIG and J. C. HOOGERHEIDE (*Journal of Bacteriology*, **41**, 557, 1941). The fact that the rate of oxygen uptake of multiplying bacteria is directly proportional to bacterial content was used as a basis for the development of a manometric method for the valuation of germicides. Inhibition in the normal rate of increase of oxygen uptake upon addition of a germicide was found to be due to a corresponding inhibition in growth. Germicides in bacteriostatic concentrations were found to have no effect on metabolic rates of bacteria, but did inhibit cell multiplication.

BOOK REVIEWS.

PHOTODYNAMIC ACTION AND DISEASES CAUSED BY LIGHT, by Harold F. Blum. 309 pages, illustrations, 16 × 24 cms. New York, Reinhold Publishing Corporation, 1941. Price $6.00.

The name photodynamic action is referred to in this book as the process of sensitization of a biological system to light by a substance which serves as a light absorber for photochemical reactions in which molecular oxygen takes part. These reactions have nothing in common with the normal oxygen metabolism of living systems. The phenomenon was observed before the turn of the century but concentrated research on the subject has been spasmodic in different directions. Recordings of work done appear in a wide variety of publications and possibilities indicated make the publishing of this American Chemical Society Monograph a valuable contribution.

The monograph starts out by furnishing a summary of the elementary principles of light and photochemistry, and reference to the delimitation of spectral regions of sunlight which elicit photobiological responses and their correlation with absorption spectra. This is the first part of the book.

Part two on photodynamic action gives evidence that the reactions probably represent oxidations of structural components of a cell which do not take place thermally, at ordinary temperatures, but which do take place photochemically, granted the presence of an appropriate photosensitizer. This is presented in the form of an analysis of the mechanism, at the end of which consideration is given of the numerous factors which modify and lend variety to the general aspect of photodynamic action.

Part three is devoted to diseases produced by light in domestic animals. This brings out the fact that diseases produced in domestic animals by light are more common than is ordinarily recognized, and on the other hand, abnormal sensitivity to light is frequently suspected where it does not exist. The economic importance of diseases brought about by photodynamic action is unquestioned and emphasizes this section of the book. Hypericism (St. Johnswort Poisoning), gleeldikkop (Yellow Thick Head), fagopyrism (Buckwheat Poisoning) and other diseases are discussed.

Part four, the concluding part of the book, is devoted to diseases produced by light in man. This starts with a historical discussion of classifications and nomenclature of diseases allegedly caused by light, followed by a tentative arrangement based upon experimental evidence. Attention is given to the response of normal skin to light, the photosensitizing action of porphyrins in man, photosensitization by substances coming into contact with the skin and by substances applied internally.

An extensive bibliography is appended, which contains the references forming the basic information of the book. The subject and author index enhances the value of the book for reference purposes.

The presentation is in logical order, and each part of the book can be used irrespective of the other parts provided proper prerequisites are available. The

book is a valued contribution which should do much to clear understanding and provide a foundation for progress in this promising field.

R. H. OPPERMANN.

THE CHEMICAL ACTION OF ULTRAVIOLET RAYS, by Carleton Ellis and Alfred A. Wells. Revised and Enlarged Edition, by Francis F. Heyroth. 961 pages, illustrations, 16 × 24 cms. New York, Reinhold Publishing Corporation, 1941. Price $12.00.

The first edition of "The Chemical Action of Ultraviolet Rays" by Ellis and Wells accomplished a great deal in furnishing a much needed summary and reference work. Advances in theory in this field in recent years has been great so that the first edition to be revised required much rewriting including altered interpretation of many reactions.

This revised and enlarged edition opens with a discussion on the nature of ultraviolet radiation—a brief historical sketch of the present knowledge of light, visible and invisible. This gives a knowledge of the physical nature of the radiations. Following this the book is divided into four parts.

Types of apparatus available for the production of ultraviolet rays are described in considerable detail in part one. The chemist who may be untrained in modern physics is given acquaintance with a minimum of the newer viewpoint necessary for an understanding of the characteristics of the useful sources of ultraviolet radiations. Then a survey is made of the various sources before each type is taken up in detail.

Part two deals with photochemical reactions by first giving an introduction to the mechanism of photochemical processes wherein a few representative reactions are discussed at length, then the literature of a wide variety of photochemical processes is summarized. It includes photosensitized processes, reactions of inorganic gases, inorganic reactions in liquids, photochemical reactions of inorganic solids, reactions of organic compounds, effects of light on halogenation reactions, etc.

The applications of photochemistry to industrial products is the subject assigned to part three. Here the treatment is somewhat empirical, recognition being given that few investigators have as yet made full use of the current theoretical advances. Attention is given to the reactions of fatty acids and the preservation of foods, processes involving the polymerization of oils—paints and varnishes, photochemistry of rubber, textiles, paper and dyestuffs, and a discussion on miscellaneous applications of ultraviolet light such as fluorescence tests for leather, applications to petroleum products, and drugs and related products.

Applications of ultraviolet rays in biology is the subject of part four. Under this heading there is presented the lethal action of ultraviolet rays and sterilization, the present state of our knowledge of the general physiological effects of this form of energy upon multicellular organisms, therapeutic applications of ultraviolet light—rickets and irradiation, the formation of D vitamins, and other biological topics.

The book represents the results of a tremendous amount of work in compiling references, extracting data and classifying results. This together with an intimate knowledge of the subject and expert composition has brought forth a

reference that is invaluable to workers in the fields of theoretical and industrial chemistry, biology and medicine.

R. H. OPPERMANN.

TEMPERATURE, ITS MEASUREMENT AND CONTROL IN SCIENCE AND INDUSTRY, under the auspices of American Institute of Physics with the coöperation of National Bureau of Standards, National Research Council. 15 × 23 cms. illustrations, 1362 pages. Reinhold Publishing Corporation, New York, 1941.

This rather large book is a record of a "Symposium on Temperature—Its Measurement and Control in Science and Industry," held in New York, November 2, 3, and 4, 1939, under the auspices of the American Institute of Physics. The Symposium was planned with the following purposes in view. (1) Coördination of the treatment of the subject of temperature in the several branches of science and engineering, (2) review of fundamental principles and a recapitulation of recent progress, (3) accumulation of contributions for a comprehensive text to be published after the Symposium, (4) emphasis on the importance of temperature as a branch of physics, (5) improvement of technical curricula through making the latest information available. The National Bureau of Standards, National Research Council, coöperated extensively in making the Symposium a success, as well as officers and committees of various engineering societies.

The arrangement of the papers in the book is under 13 different classes. They are temperature and temperature scales, precision thermometry, education, natural sciences, temperature in biology, temperature and its regulation in man, automatic temperature regulation and recording, special applications and methods, general engineering, metals and ceramic industries, oil industries, optical and radiation pyrometry, and thermometric metals and alloys. Some 125 papers were presented and informally discussed by the best authorities on the subjects. The book also contains twenty-five tables of generally useful data, a Glossary of technical terms and complete author and subject indexes. Much of value can be found in this book by chemists, biologists, geologists, engineers, physicians and those bearing many other professional designations.

R. H. OPPERMANN.

PROCEEDINGS OF THE MICHIGAN-LIFE CONFERENCE ON NEW TECHNICOLORS IN TRANSPORTATION. 231 pages, illustrations, 15 × 23 cms, published by the University of Michigan.

Last November the Michigan-Life Conference was convened at the University of Michigan, Ann Arbor. It was sponsored jointly by the University and Life to provide a forum for the exchange of information on new trends and technics in the great fields of road, rail, water and air transportation. This little booklet contains the papers and addresses delivered at the full sessions of the Conference and at associated meetings. The authors include leaders from the various industries such as Charles F. Kettering of General Motors, D. A. Wallace of Chrysler Corporation, Dr. Gustav Egloff of Universal Oil Products Co., Otto S. Schairer of Radio Corporation of America, Edwin H. Land of the Polaroid Corporation, C. R. Smith of American Air Lines, Inc., and others. The papers are well illustrated and give the views of these men in their particular fields.

R. H. OPPERMANN.

PREVENTION OF THE FAILURE OF METALS UNDER REPEATED STRESS, A Handbook prepared for the Bureau of Aeronautics, Navy Department, by the staff of Battelle Memorial Institute. 273 pages, illustrations, 16 × 24 cms., New York, John Wiley & Sons, Inc., 1941. Price $2.75.

There is no doubt of the importance of this subject to the aircraft industry. When consideration is given to the high speeds, the sudden and varied stresses, the multitude of parts, and the contributions of the designers, machine shop superintendents and workmen of the aircraft industry, appreciation is had of the magnitude of the subject and the possibilities of fatigue failures. The Bureau of Aeronautics of the United States Navy Department in 1939 recognized the need of making available the engineering principles involved in the precautions through which fatigue failures might be prevented, and took steps which resulted in the commissioning of the Battelle Memorial Institute to compile the published literature from scattered sources and unpublished information in the files of the Bureau of Aeronautics and the National Bureau of Standards relating to the most important available data. The result of the compilation and coordination of the material is this book.

The book relates the story of failures of parts of aircraft due to notches, nicks, keyways, rough oil holes and screw threads, scratches, rough surfaces, quenching and grinding cracks, tool marks and the like. It states that because of conditions of local repeated loading, the part had to fail following natural laws through some slip of the designer, machinist or inspector. Considerable attention is given to welds, riveted joints, surface layers and coatings, corrosion fatigue, peak stresses due to high duty and from harmonic vibration and other factors. Propellors, crank shafts, pistons, nuts, bolts, connecting rods, springs are some of the parts examined. It naturally follows that in a book of this nature photographs play a very important part. This book contains many of them excellently done. Curves, charts, tables and diagrams supplement the text.

The book contains some 106 pages of discussion of the various technical features of failures. Then there are twenty-eight appendices, each devoted to a particular subject, the last being a glossary of terms used in discussing mechanical properties of metals. This is followed by an extensive bibliography of references referred to throughout the book, an author index and a comprehensive subject index.

Published under the auspices of the National Research Council of the National Academy of Sciences, this book fills a great need of supplying data to engineers and mechanics which heretofore has been seldom accessible and too often couched in technical language beyond the understanding of those responsible for the maintenance of aircraft. Emphasis is placed on the fact that much of the information here supplied has been obtained through experience only, which makes it doubly valuable. Everyone who has any responsibility in the maintenance of aircraft should have a copy of this book.

R. H. OPPERMANN.

AN INTRODUCTION TO THE THEORY OF NEWTONIAN ATTRACTION, by A. S. Ramsey, M.A., 184 pages, illustrations, 14½ × 22½ cms. Cambridge University Press, London, England, 1940. Price $2.50.

Here is a subject useful in connection with dynamical astronomy, which is treated here particularly from the standpoint and for students of college grade in

Great Britain. The book opens with an exposition of many of the theorems in pure mathematics especially required for study of the subject. Then it proceeds through simple applications in gravitational attraction and potential where attention is confined to points external to the attracting matter. This is followed by consideration of what meaning to attach to the same terms at points inside the attracting matter, theorems of Laplace, Poisson and Gauss, Green's theorem, the study of harmonic functions in-so-far as they apply to the immediate subject, and finally an investigation of the attraction of ellipsoids.

The book gives a vigorous mathematical treatment with many examples for exercise. To determine just where it would fit into the American process of education would require a knowledge of the English system plus a close examination of the contents

R. H. OPPERMANN.

FOURIER SERIES AND BOUNDARY VALUE PROBLEMS, by Ruel V. Churchill, First Edition, 206 pages, 16×24 cms. New York, McGraw-Hill Book Company, Inc., 1941. Price $2.50.

The author, in the preface of this book states that the first objective is to introduce the reader to the concept of orthogonal sets of functions and to the basic ideas of the use of such functions in representing arbitrary functions. The most prominent special case, that of representing an arbitrary function by its Fourier series is given special attention while the representation of functions by series of Bessel functions and Legendre polynomials are also treated individually but somewhat less fully. The second objective is a thorough acquaintance with the classical process of solving boundary value problems in partial differential equations, with the aid of those expansions in series of orthogonal functions. The boundary value problems treated here consist of a variety of problems in heat conduction, vibration and potential. Emphasis is placed on the formal method of obtaining the solutions of such problems.

The book should be suitable for students of physics, engineering and both pure and applied mathematics.

R. H. OPPERMANN.

FLUID MECHANICS, by Glen N. Cox, and F. J. Germano, 274 pages, illustrations, 16 × 24 cms. New York, D. Van Nostrand Company, Inc., 1940. Price $3.00.

The increasing use of gases and liquids other than water in industry has focused considerable attention on the subject of fluid mechanics. This furnished incentive for many investigators whose work demonstrated that although a complete mathematical treatment of the subject was impossible, certain criteria for similarity of flow existed which permitted the results of an experiment with one fluid to be used in predicting the behavior of an entirely different fluid under similar circumstances. There resulted order to the science of fluid mechanics, the subject of this ext.

Aimed directly at furnishing knowledge to apply in industry the text requires the usual preparation in mathematics, mechanics and physics. It is divided roughly into five parts, namely hydrostatus, measurement of fluids, transportation of fluids in closed and open channels, dynamics of fluids and centrifugal pumps.

The work opens with a treatment on definitions and properties of fluids and proceeds through chapters on pressure in fluids and force of fluid pressure on areas. At this point a brief chapter describing the meaning of viscosity, characteristics and viscosimeters is inserted together with another chapter on dimensional analysis in order to clear up any vague ideas concerning these topics before the study of measuring devices is studied. Measuring devices with regard to non-compressible as well as compressible fluids are covered. Pipe flow, open channel flow, dynamic action of fluids and centrifugal pumps are subsequent topics.

The text is well illustrated with drawings and diagrams. The problem material is carefully selected and the subject index is comprehensive. The subject is adequately covered and the text should prove valuable in instruction.

R. H. OPPERMANN.

PHYSICAL SCIENCE IN ART AND INDUSTRY, by E. G. Richardson, 293 pages, illustrations, plates, 15 × 23 cms., London, The English Universities Press Ltd. Price $3.50.

The title of this book is quite indicative of its contents, an explanation of the part that physics plays in recent developments in art and industry. As such its position is between the text on physics and the technique of the application of physical principles to practice, while in no sense is it a text on applied physics. Therefore, a reader with a fair understanding of the elements of mechanics, heat, electricity and magnetism will find little difficulty in following the story.

Fifteen chapters of the book are given to different forms of industry and art. The physics of locomotion is covered separately through vehicles, ships and aeroplanes. Then there follows communication physics, physics and pottery, the culinary arts, the farm, the mine, fine art, building materials, architecture, music, textiles, and the art of war. Under these different topics there is a multitude of interesting explanations which should create and sustain attention for their cultural value in addition to showing the practical value of the study of physics.

The book is essentially British. Where it is necessary for the author to refer to certain industries or objects as illustrative examples of the discussion, these are generally familiar to British readers and in many cases strange to the American. This is not a serious drawback since the book was published in Great Britain and for British readers, and American readers should attempt to orient themselves accordingly. The book follows a logical sequence and should prove interesting and helpful to many.

R. H. OPPERMANN.

ORGANIC CHEMISTRY, AN INTRODUCTION TO THE CARBON COMPOUNDS, by Nicholas D. Cheronis, 728 pages, 15 × 24 cms., New York, Thomas Y. Crowell Company, 1941. Price $4.00.

This subject has assumed such great importance and application in ever widening fields that there is a constant demand on those responsible for producing men able to apply knowledge of it to modernize methods of teaching so as to create and sustain interest to the end of greater efficiency in absorption of the subject matter. No little weight falls on the instruction on the fundamentals of organic chemistry. The author of this text states that for many years he has

been working with the problem, seeking to provide a clearer and more logical method of approach. Viewing the situation of the student who is qualified for the systematic study of carbon compounds, a number of difficulties become apparent. The relations and principles concerning the elements and compounds with which the student is familiar do not seem at first sight to serve as guides through the large number of reactions which organic compounds undergo. Many of the reactions do not proceed at the instantaneous speed so common among the inorganic chemical changes. Further confusion is added by the tendency of organic reactions to proceed in several directions and to yield more than two products. Finally, some organic molecules undergo internal changes with relative ease, even on standing, and thereby form new substances. With all this in mind and a background of considerable experimentation with a wide variety of students, the author has produced this text as a result.

The arrangement of the material differs somewhat from the usual. Generally the book may be divided into a number of parts. What may be called part one is apparently intended to orient the student in the field—to place him in a position to study what follows. This consists of an introduction with the object to project the study of organic chemistry against a background with which the student is assumed to be familiar, namely, inorganic chemistry. Then general methods utilized in the purification of organic compounds and the chief qualitative and quantitative methods of analysis are given. A review is made of the modern theory of atomic structure and the mode of compound formation. Then the theory of isomerism is discussed with the relation between reaction properties, structure, and classification of carbon compounds.

What may be grouped as part two of the book contains a study of the hydrocarbons and the simpler groups of organic compounds without the usual separation into aliphatic and aromatic. Here there is an introduction to benzene hydrocarbons through cyclo-olefins. The more complex benzene hydrocarbons are discussed later. The coverage includes the monohalogen and monohydroxy compounds, the amines, and a review and expansion of the elementary theories of organic chemistry correlated with the material thus far presented. Nitro compounds, the polyhalides, ketones, cyanides, and carboxylic acids are subsequent subjects.

Part three begins with a treatment of the more complex groups of organic compounds. Dicarboxylic acids are followed by halogen and hydroxy acids, polyhydroxy, and polyfunctional carbonyl compounds. More complex compounds are encountered in the discussion of carbohydrates, amino acids and proteins. In this part there is given a simple treatment on the more complex aromatic compounds. The book ends with an elementary introduction to the synthesis of polymers and their applications with a brief description of the most important commercial synthetic resins, rubbers and fibers.

The book is an interesting text from many angles. A feature is the clearness of presentation and descriptive matter. There is a list of problems and exercises at the end of each of the forty-one chapters, and in the back a rather large name index appears. The book was primarily intended for the usual year's course, but suggestions are offered for its use in briefer courses. Teachers of the subject would do well to examine it for classroom use.

R. H. OPPERMANN.

THE WORLD AND THE ATOM, by C. Moller and Ebbe Rasmussen. 199 pages, plates, illustrations, 15 × 23 cms. New York, D. Van Nostrand Company, Inc., 1941. Price $2.75.

To produce a book which is essentially a translation from the technical to the language of the layman is a task worthy of the broadest intellectual minds. Many efforts of this nature have been made, especially in books which are aimed toward what might be termed popular reading, and as a result there are available books of various grades depending upon how far toward popular reading the translation was made. The World and the Atom may be placed in the category midway between the first step after the technical treatise and the popular work.

The book is divided into three parts preceded by an introduction. The Golden Age of the Great Discoveries, the heading of the first part, tells of the satisfaction felt in the field of physics in the era of the latter part of the past century, when physicists were more or less at one in believing that all the great discoveries had been made and it simply remained to apply physical principles to technology. It tells the story of what happened then—of one remarkable discovery after another which were quite at variance with the previous smoothly rounded picture. The discoveries of radium, electrons and Roentgen rays and the vast unexplored field which they opened are given attention.

The researches which followed the discoveries of the Golden Age are described in part two of the book. Here there is explained Bohr's atomic theory, the origin of the Roentgen spectra, the card-index of the elements and the atomic number and the latest triumphs of atomic mechanics.

The last part of the book deals with another Golden Age of great discoveries —the present. Here is treated a new department of physics, nuclear physics, which is the result of our knowledge of the atomic nuclei. An interesting description is given of their properties with the warning that it must not be taken verbatim and that the reader should be ready for surprises emanating from new discoveries.

The book is a good translation from the original in Danish to English. A brief foreword is given by Professor Niels Bohr explaining some of the background of the book and some of the reasons for it.

The language is easy to read and understand, although the book cannot be classed with popular reading. It has appeal to the serious minded reader as broadly informative without requiring a great deal of physical, chemical or mathematical theory as a prerequisite.

R. H. OPPERMANN.

PUBLICATIONS RECEIVED.

Photographic Emulsion Technique, by T. Thorne Baker, 263 pages, 14 × 20 cms. Boston, American Photographic Publishing Co., 1941. Price $4.00.

Strength of Materials, Part II, Advanced Theory and Problems, by S. Timoshenko. 510 pages, illustrations, 16 × 24 cms. New York, D. Van Nostrand Company, Inc., Second edition, 1941. Price $4.50.

Lange's Handbook of Chemistry, A reference volume for all requiring ready access to chemical and physical data used in laboratory work and manufacturing,

by Norbert Adolph Lange, Ph.D. 1909 pages, 14 × 20 cms. Sandusky, Ohio, Handbook Publishers, Inc., Fourth edition, 1941. Price $6.00.

The Photochemistry of Gases, by William Albert Noyes, Jr., and Philip Albert Leighton. 475 pages, illustrations, 16 × 24 cms. New York, Reinhold Publishing Corp., Price $10.00.

Bell Telephone System, Monographs: B-1290, A New Mirror Light-Modulator, by W. R. Goehner. 8 pages, illustrations. B-1291, Time Division Multiplex Systems, by W. R. Bennett. 23 pages, illustrations. B-1292, Steady State Delay as Related to Aperiodic Signals, by R. V. L. Hartley. 13 pages, illustrations. B-1293, Steady State Solutions of Transmission Line Equations, by S. O. Rice. 48 pages. B-1294, Engineering Problems in Dimensions and Tolerances, by W. W. Werring. 20 pages, illustrations. B-1295, Room Noise Spectra at Subscribers' Telephone Locations, by Daniel F. Hoth. 15 pages, illustrations. B-1296, Reduction of Magnesium Oxide by Tungsten in Vacuum, by George E. Moore. 12 pages, illustrations. B-1297, Calculation of the Torque on a Ferromagnetic Single Crystal in a Magnetic Field, by R. M. Bozorth and H. J. Williams. 16 pages, illustrations. B-1298, Micro-Gas Analysis Methods and Their Application to Research, by L. A. Wooten. 14 pages, illustrations. B-1299, New Microphone Providing Uniform Directivity Over Extended Frequency Range, by R. N. Marshall and W. R. Harry. 43 pages, illustrations. B-1300, Operation of Electrsotatic Photo-Multipliers, by R. C. Winans and J. R. Pierce. 20 pages, illustrations. B-1301, Spectral and Total Thermal Emissivities of Oxide-Coated Cathodes, by George E. Moore and H. W. Allison. 12 pages, illustrations. 12 pamphlets, 15 × 23 cms. New York, Bell Laboratories, 1941.

CURRENT TOPICS.

The Weather Man.—A recent partial survey of the utilization of weather and climatological data provided by the United States Weather Bureau indicates an annual saving to agriculture, industry, commerce and the people in general amounting to hundreds of millions of dollars annually according to an announcement by the Department of Commerce. The rank and file of citizens doubtless do not regard the Weather Bureau as a great money-saving agency. It has long been common practice to grumble about the weather and, when conditions do not suit individual fancy or convenience, to belabor the Weather Man. In daily weather forecasts simple statistics give the Weather Man an accuracy average of 85 to 90 out of a possible 100, despite the fact that conditions often change with great rapidity. With modern improvements the percentage of accuracy tends to increase. Daily forecasts of weather in districts and regions are only one of many important functions of the Weather Bureau. Observations on which these forecasts are based are dovetailed with the observing networks for the hurricane warning service, the cold-wave, frost warning and farm crop weather service, the flood warning, aviation weather, winter sports and forest-fire warning services, and, the general climatological service. All these activities are interrelated and in common depend upon uniform observation made throughout the country at 1-, 3-, or 6-hourly intervals, plus reports received from vessels at sea, from stations on distant islands, and from the ingenious radiosonde, which transmits reports automatically by radio covering conditions at stratospheric altitudes.

R. H. O.

"Electric Eye" Adapted to Measuring Protein in Wheat.—The versatile "electric eye" has been given the new task of determining the protein content of wheat, grain specialists of the U. S. Department of Agriculture report. Research indicates that the photometric determination of protein content requires less time and much less expensive equipment than the conventional Kjeldahl protein test, and is especially suited for large-scale routine work. The results obtained by use of the electric eye are also expected to provide a somewhat better index of ultimate bread-baking quality than the Kjeldahl test. In making tests with the new apparatus

the wheat is ground and the proteins extracted by chemical means. By the addition of other chemicals, the glutenous proteins are brought into a stable colloidal suspension, and when a beam of light is focused on a standard tube containing this suspension, part of the light is prevented from passing through by the protein present. Thus, the amount of light passing through the tube is an index of protein content and is measured accurately and nearly automatically by a photometer equipped with an electric eye or photoelectric cell. The method has been so devised that the non-gluten proteins of the wheat—the bran and germ proteins—have relatively little effect in obstructing the beam of light. For this reason the gluten proteins, the only proteins of importance from the standpoint of ultimate bread-baking value, are determined nearly independently from the other proteins and nitrogenous substances present in the wheat. The most expensive piece of apparatus used in the new method of protein-content determination is the photometer equipped with an electric eye. This instrument is less expensive than the moisture testers and dockage testers now in use however, and officials hope to reduce the cost still further. Improvements are also sought in the apparatus.

R. H. O.

Water Power.—The United States led the world at the end of 1940 in the horsepower capacity of water wheels in water power plants, the Geological Survey of the United States Department of the Interior reported recently. With an installed capacity of 19,000,000 horsepower in water wheels, this Nation had more than twice as much water wheel horsepower as Canada, in second place. Canada was rated as having 8,584,000 horsepower, with Italy in third place with 6,250,000. The total capacity of water wheels in power plants throughout the world was 69,400,000 horsepower at the end of the year. As the installed capacity in 1920 was 23,000,000 horsepower, this represents an increase of 202 per cent. in the 20-year period. The Geological Survey pointed out that there has been an increase of about 1,800,000 horsepower in the capacity of water power plants in the Western Hemisphere since 1938. At present, in the United States and Canada alone, there are under way power projects totaling more than 8,000,000 horsepower. Many of these require only the installation of water wheels on foundations already built, or the installation of additional units at plants already in operation. A number of important water power projects were reported during 1937–39 as being contemplated and under way in many countries of the Eastern Hemisphere, notably Italy, Japan, Manchukuo, Thailand, and the Soviet Union, totaling

millions of horsepower. The status of these projects at the present time is indefinite, as the starting and completion of the construction of water power plants has been delayed in all parts of the world, except in North America, by the disruption of transportation and industry brought about by war conditions.

R. H. O.

Treatment Prolongs Life of Sandbags.—The defense research program has developed a method of treating sandbags so that they will give more satisfactory service—military or civilian. Preparedness for floods calls for huge reserve supplies. Countries engaged in warfare require hundreds of millions of sandbags to protect civilian life and property and for use in combat areas. It is reported that the British have procured to date more than one and a half billion sandbags. Sandbags made from untreated fabrics, either cotton or burlap, have proved unsatisfactory in this country as well as in England. They rot too quickly, either in storage or in service. Recently when an emergency in one of the European nations called for withdrawal from storage of several hundred million sandbags, more than one half of the bags had deterioriated so badly that they were unfit for use, although they had been stored for only a comparatively short time. Research has proved that this rapid deterioration can be prevented. As a result of investigations by the Bureau of Agricultural Chemistry and Engineering of the U. S. Department of Agriculture, a chemical treatment has been developed for preserving the fabric. This treatment works equally well on cotton or jute. The War Department's latest invitation for bids on sandbags specified this treatment.

R. H. O.

Electric Test Diagnoses Health and Vigor of Trees.—Federal entomologists are interested in recent studies of electrical conditions in growing trees, and the chance that it may be possible to work out a method of diagnosing the health and vigor of a tree even before signs of low vitality show in the leaves and new growth. An important application would be to measure a tree's susceptibility to insect attack. In studies of several varieties of softwoods and a few hardwoods, Thaddeus Parr of the Federal Bureau of Entomology and Plant Quarantine found that in most cases there was a slight but definite voltage gradient within a tree. During the vigorous growth period in the spring, the plus voltage is toward the tip of the tree. Later in the season, when the tree is storing food material in the roots, the plus is toward the base. In trees attacked by borers—or so unthrifty as likely to be attacked—the reaction is

abnormal, either weaker than in a normal tree or in the reverse direction. Scientists have developed a comparatively simple but very sensitive voltmeter that can be carried to the woods and that will indicate the direct current potentials in quick readings. Another practical use for such a system of electrical diagnosis would be to indicate low vigor in shade trees and ornamentals and the need for water, fertilization, or drainage.

R. H. O.

Coal for Water Purification.—Coal from refuse dumps of mines can be utilized to make drinking water clear, tasteless, and odorless, it has been shown through experiments conducted by the Bureau of Mines at its Southern Experiment Station, Tuscaloosa, Alabama. According to a report just issued by the Bureau, investigations carried out in coöperation with the University of Alabama have demonstrated that the refuse from coal mine washeries generally contains some good coal mixed with the waste, and that this coal can be readily made into activated carbon, a substance which is used now for water purification. The process of water purification using this material is approximately as follows: Mud or fine colloidal water which is usually present in raw water obtained from a lake, river, pond or reservoir is flocculated by the mechanically regulated addition of chemical reagents, such as alum or sodium silicate or other substances. Then, after the solids have partly settled in the basins, chlorine and ammonia are added to kill the bacteria. After a time, to allow for settling, the water may be sparkling and clear, and free of bacteria, but may still have a very pronounced taste and odor. Polluted waters have odors which are described generally as earthy, peaty, grassy, musty, moldy, fishy and sulfurated. If the pollution is bad, odors classed as hydrocarbon, medicinal, chlorinous, or mercaptan may be noted. Phenol in the water in concentrations too small to be detected by taste or smell will produce a bitter taste after the water has been chlorinated. Powdered activated carbon is now added to the odorous water as a water suspension and mixed thoroughly so that the finely divided carbon comes in contact with all the water. The carbon remains in contact with the water for several hours, finally settling to the bottom of the basin. Any remaining carbon is removed by sand filters, and the water emerges clear, sparkling, tasteless, odorless and germ-free and is ready to be piped to the consumer. The Bureau's experiments have shown that activated carbon for use as a water purification agent can be made best from that fraction of the coal removed from refuse dumps which yields a low ash, and

that the best method for activating the carbonaceous material is by means of partial oxidation of the carbon at a high temperature with steam.

R. H. O.

New Cotton Insulation Makes a Comfortable House.—Cotton insulation is effective in such extremes of climate as Point Barrow, Alaska, and the tropical Wake Islands, tests have shown. This new insulation is made of clean new cotton, treated to make it flame proof. It is glued to a moisture-proof backing, and when this backing is tacked to the studding the material does not sage or settle. Household insects such as clothes moths, carpet beetles, or bedbugs, do not attack clean cotton. The U. S. Department of Agriculture, interested in developing new uses for cotton, finds cotton insulation for dwelling houses is one of the most promising of these new uses. More than a bale of cotton is needed for the insulation of a four room house, twenty-four by thirty-two feet with walls eight feet to the eaves. The Surplus Marketing Administration is encouraging further use of cotton insulation by granting payments to manufacturers of this product during an experimental period. The cotton insulation comes in strips of desired thickness and in widths suited to spaces between studding. One type has the cotton glued to a backing of moisture resistant paper. In another, the cotton is glued between metal foil to shut out dampness. Both types have proved efficient in keeping a house warmer in winter and cooler in summer. They are relatively inexpensive, easily installed, and suited to remodeling of old houses.

R. H. OPPERMANN.

Soybean Paint Durable.—The first satisfactory lot of 100 per cent. soybean oil paint tested by the U. S. Regional Soybean Industrial Products Laboratory was mixed recently, said A. J. Lewis of the laboratory staff. Previously the laboratory had made up several all soybean oil varnishes. This first lot of paint was tested against a similar linseed oil paint for drying, brushing, flowing, and other qualities, and was considered fully satisfactory except for somewhat slower drying. Since then, the laboratory has developed chemical treatments that improve drying of the paint film. But Mr. Lewis also commented that for purposes in which rapid drying is not important a slow drying paint if allowed plenty of time to harden between coats should be more durable than a fast drying paint, since the slow drying oil would probably oxidize more slowly.

R. H. OPPERMANN.

Auto Safe from 3 Million Volt Discharge.—(Power Plant Engineering, Vol. 45, No. 8.) While a research engineer sat at the wheel, 3 million volts of "lightning" was discharged into a car in a recent demonstration at the Westinghouse high-voltage laboratory at Trafford, Pa., without damaging the automobile or injuring its driver. The engineer, Dr. Gilbert D. McCann, said the demonstration with laboratory lightning proved for the first time that occupants of a steel-topped automobile are safe from natural lightning attacks. Although the laboratory lightning stroke hit the car just 6 in. above his head, he was safe from injury because modern steel car bodies are effective shields against lightning. If lightning struck a car on a highway, the extremely high current electricity should be conducted through the metal body to earth without injuring the occupants. Before climbing into the car Dr. McCann aimed the lightning gun—a 3,000,000 v. surge generator—at the unoccupied sedan and fired several bolts. Only traces of damage after the test were small burn marks about the size of a pencil eraser on the metal top. When lightning crackled against the car roof over his head, Dr. McCann felt no sensations and probably heard less noise than the spectators. Rubber tires have nothing to do with the safety of the occupants, Dr. McCann explained. In his demonstration, the electricity traveling from the car to ground had to jump over a tire. If lightning hit a radio antenna extending above the car top, it would not endanger the occupants. The radio probably would be damaged, but the electricity would reach ground through the car body by jumping over the insulating gap where the antenna enters the car. Nor does the gasoline tank present a serious lightning hazard. The protected position of tanks on modern cars makes it almost impossible for them to be hit by lightning, especially since lightning seeks its nearest target which would be the top of the car. Dr. McCann explained that when lightning struck the sedan in the high voltage laboratory, the potential of the car and his body rose to about 200,000 v. while the ground remained at zero potential. This condition resulted when the car became part of the path of lightning as it headed for the ground. However, he felt no electrical effect because there was no difference in voltage produced across any part of his body. But a person on the ground touching the automobile or even standing near it during the lightning strokes would have been in danger because of the difference in voltage that would be produced in his body.